Patent Application

OIPE JC54 AUG 07 1998 PATENT & TRADEMARK OFFICE

BARNES & THORNBURG
11 South Meridian Street
Indianapolis, Indiana 46204

Transmittal Date: August 4, 1998

Applicant: Curtis L. Taylor

Serial No.: 08/954,291

Filing Date: October 17, 1997

Title: OXYGEN-FUEL BURNER WITH INTEGRAL STAGED OXYGEN SUPPLY

Group: Unknown Examiner: Unknown

Attorney Docket No.: 3053-28781

ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

Sir:

Transmitted herewith is an amendment in the above-identified application.

The fee has been calculated as shown below.

CLAIMS AS AMENDED							
	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NO. PREVIOUSLY PAID FOR	PRESENT EXTRA	SMALL ENTITY		OTHER	
TOTAL CLAIMS	120	* 110	10	Rate x $11		Rate x $22	220
INDEP. CLAIMS	15	** 14	1	Rate x $41		Rate x $82	82
TOTAL FEE FOR ADDITIONAL CLAIMS						302	

* If the "Highest Number Previously Paid For" in this space is less than 20, write "20" in this space.

** If the "Highest Number Previously Paid For" in this space is less than 3, write "3" in this space.

______ An Extension of Time for _____ months is hereby requested under 37 C.F.R. § 1.136(a). The required fee for filing this extension is: ______

TOTAL FEE THIS AMENDMENT 302

X A check in the amount of $ 302 to cover the total fee for this amendment is attached.

______ Statement(s) of Status as Small Entity Under 37 C.F.R. 1.27 has (have) been filed.

______ Statement(s) of Status as Small Entity Under 37 C.F.R. 1.27 is (are) being submitted herewith.

X Proposed Amendments to the Drawings(3 shts.drg)

X Statement Under 37 C.F.R. §3.73(b)

X Response to Notice to Missing Parts - PTO Form 1533

x Supplemental Declaration

X Check in the amount of $1640 for the late filing of the Declaration and a 4-month extention of time

X Offer to Surrender Original Patent under 37 C.F.R. §1.178

~~The Commissioner is hereby authorized to charge any additional filing fees under 37 C.F.R. §1.16 or processing~~ fees under 37 C.F.R. §1.17 which may be required, or credit of any overpayment, to Account No. 10-0435. A duplicate copy of this sheet is enclosed.

Jill L. Woodburn

Attorney of Record

Printed Name Jill L. Woodburn

Registration No. 39,874

10/97

A

10/17/97 JC551 U.S. PTO

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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group: Unknown

Attorney Docket: 3053-28781

Applicant: Curtis L. Taylor

Invention: OXYGEN-FUEL BURNER WITH INTEGRAL STAGED OXYGEN SUPPLY

Serial No: Unknown

Filed: Herewith

Examiner: Unknown

Certificate Under 37 CFR 1.10

Express Mail Label No.: EM343389952US

Date of Deposit: October 17, 1997

I hereby certify that this correspondence is being deposited with the United States Postal Service's "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231

Jill L. Werling
Typed or Printed Name of Person Mailing Paper or Fee

Jill L. Werling
Signature of Person Mailing Paper or Fee

Application To Reissue
U.S. Patent No. 5,458,483
Issued October 17, 1995
on U.S. Application Serial No.163,424
Filed December 8, 1993

TRANSMITTAL LETTER

Assistant Commissioner
for Patents
Washington, D.C. 20231

Sir:

The undersigned encloses a declaration by inventor (unsigned)/assent by assignee (unsigned), an offer to surrender original patent under 37 C.F.R. § 1.178(unsigned)/assent by assignee to reissue (unsigned), an order for a Certified Abstract of Title, an application to reissue U.S. Patent No. 5,458,483 including original claims 1-68 and new claims 69-110, an information disclosure statement, and an associate power of attorney.

The subject matter of the new claims presented herein is disclosed throughout the specification and drawings of the original patent. Support for the new claims may be found

particularly at col. 4 lines 14-26 and lines 64-67; col.5 lines 1-3, lines 14-35, and lines 58-66; col. 6 lines 3-18 and lines 54-61; col. 7 lines 36-65; col. 8 lines 3-13; and Figs. 1-8. It is respectfully maintained that the support for the new claims found throughout the specification and drawings is sufficient to satisfy 35 U.S.C. §112, first paragraph and to convey to those skilled in the art that applicant invented the subject matter of the new claims. In addition, it is contended that the specification and drawings as originally filed adequately demonstrate that applicant considered the material now claimed to be his invention in accordance with MPEP §1412.01. Therefore, it is respectfully maintained that new claims 69-110 submitted herewith are fully supported by the original patent and a reissue patent that includes said new claims would be for the invention disclosed in the original patent as required under 35 U.S.C. §251.

It is respectfully requested that the filing fee of $2,124.00 associated with the filing of this application for reissue of U.S. Patent 5,458,483 be charged to the Account of Barnes & Thornburg, Deposit Account No. 10-0435 with reference to our matter no. 3053-28781. In addition it is respectfully requested that any shortages in fees, be charged, or any overpayment in fees be credited, to the Account of Barnes & Thornburg, Deposit Account No. 10-0435 with reference to our matter (3053-28781). An extra copy of this paper is enclosed to facilitate handling of this matter.

Respectfully Submitted,

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INDS02 JLW 169656

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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group:	Unknown
Attorney Docket:	3053-28781
Applicant:	Curtis L. Taylor
Invention:	OXYGEN-FUEL BURNER WITH INTEGRAL STAGED OXYGEN SUPPLY
Serial No:	08/954,291
Filed:	October 17, 1997
Examiner:	Unknown

Certificate Under 37 CFR 1.8(a)

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to Assistant Commissioner for Patents, Washington, D.C. 20231

on Aug. 4, 1998

Jill L. Woodburn

Jill L. Woodburn (Reg. No. 39,874)

Dated: Aug. 4, 1998

Application to Reissue
U.S. Patent No. 5,458,483
Issued October 17, 1995
on U.S. Application Serial No. 163,424
Filed December 8, 1993

PRELIMINARY AMENDMENT

Box Missing Parts
Assistant Commissioner
for Patents
Washington, D.C. 20231

Sir:

Preliminary to the examination of the above-referenced case, it is respectfully requested that the Examiner enter the following amendments and consider the accompanying remarks.

In the Specification:

Replace the paragraph beginning at Col. 4 line 64 with the following:

As shown in FIG. 1, a staged oxygen burner assembly 10 includes a burner block 12, a frame 14 mounted on an inlet end of the burner block 12, and a hollow oxygen-supply housing 16 mounted on the frame 14 by means of removable fasteners 18. A fuel nozzle 20 is positioned to lie inside the hollow oxygen-supply housing 16 and is retained in place by means of a removable collar 22. It is easy to replace nozzle 20 because of the modular nature of the staged oxygen burner assembly 10. For example, to convert the staged oxygen burner assembly 10 from a gas-fired unit to an oil-fired unit, it is necessary only too replace the gas-fuel nozzle module shown in Fig. 3A with the oil-fuel nozzle module shown in Fig. 7. As shown in Fig. 1, removable collar 22 includes an outer surface 220, an opposite inner surface 222 facing toward burner block 12, and an external side wall 224 extending between outer and inner surfaces 220, 222. Illustratively, external side wall 224 includes a plurality of generally flat bounding surfaces 226 that are configured to cooperate with a corresponding socket wrench (not shown). Referring now to Fig. 3A, collar 22 further includes an internal side wall 228 defining a passageway 230 between outer and inner surfaces 220, 222. Internal side wall 228 includes a threaded portion 232 positioned to lie adjacent inner surface 222, a limit tab 234 positioned to lie adjacent outer surface 220, and a recess 236 positioned to lie between threaded portion 232 and limit tab 234. As shown in Fig. 3A, threaded portion 232 presses rear lip portion 75 into engagement with mounting fixture 71 and limit tab 234 engages mounting fixture 71 to support gas conduit 20.

Replace the paragraph beginning at Col. 6 line 19 with the following:

A gas conduit 70 is disposed within housing 12 and has means thereon for directing a gaseous fuel therethrough to be expelled from gas conduit 70 and to mix with the

oxygen for burning in a sustainable flame. Gas conduit 70 may preferably have one or more O-ring seals 72 disposed at a mounting fixture 71 formed near the outer end of the gas conduit for effectuating a seal with a rear lip portion 75 of the tip 62 of hollow shell 54. As shown in Fig. 3A, mounting fixture 71 includes an outer end 250 and an opposite inner end 252 facing chamber 56. In addition, rear lip portion 75 of hollow shell 54 includes an inner surface 239 facing O-ring seals 72 and an opposite outer surface 240 facing removable collar 22. Threaded portion 232 of collar 22 engages outer surface 240 of rear lip portion 75 to removable collar on hollow shell. In addition, limit rib 234 engages mounting fixture 71 to trap mounting fixture between limit rib and inner surface 239 of rear lip portion 75 within passageway 230.

Replace the paragraph beginning at Col. 10 line 6 with the following:

As shown in Fig. 7, the burner assembly 210 includes a nose portion or nose piece 90 provided with a central discharge orifice or annular opening 92. An oil-delivery assembly 152 is shown centrally mounted within the oxygen-supply housing 16 by means of a spider or centering ring 154. The fuel-delivery assembly 152 is shown to include an inlet body portion 155, a central body portion 156, and a burner tip portion 158. Body portion 155 includes a mounting fixture 271 for effectuating a seal with a rear lip portion 75 of the tip 62 of hollow shell 56. Mounting fixture 271 includes an outer end 350 and an opposite inner end 352 facing chamber 56. Threaded portion 232 and limit rib 234 of removable collar 22 cooperate to support burner tip portion 158 in an installed position within the inlet opening 34. Thus, to convert staged oxygen burner assembly 10 from a gas-fired unit to an oil-fired unit, it is necessary only to remove collar 22 from rear lip portion 75 of hollow shell 56, pull nozzle 20 from chamber 56, insert fuel-delivery assembly 152 into passageway so that burner tip portion extends through inlet opening 34, and couple collar 22 to rear lip portion 75 and mounting fixture 271. A central fuel-oil

passageway 160, formed in a channel member 162, is provided with an inlet connector for receiving a suitable supply of fuel such as oil.

In the Claims:

Please add new claims 111-120 as follows:

111. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

an oxygen-supply housing defining an oxygen chamber configured to receive a supply of oxygen and a base wall positioned to lie adjacent to the burner block, the base wall being formed to include an aperture positioned to lie in alignment with the inlet opening and to pass oxygen from the oxygen chamber into the flame chamber,

a fuel-discharge nozzle configured to discharge fuel, and

a removable collar engaging the oxygen-supply housing and the fuel-discharge nozzle, the collar being formed to support the fuel-discharge nozzle within the inlet opening of the burner block to discharge fuel into the flame chamber formed in the burner block.

112. The burner assembly of claim 111, wherein the removable collar engages the fuel-discharge nozzle and threadedly engages the oxygen-supply housing.

113. The burner assembly of claim 112, wherein the oxygen-supply housing includes an annular lip defining a cylindrical nozzle aperture receiving the nozzle and the removable collar includes an annular side wall surrounding and engaging the annular lip.

114. The burner assembly of claim 111, wherein the oxygen-supply housing includes a hollow shell that has a tip positioned to lie spaced apart from base wall and the removable collar engages the tip of the hollow shell and the fuel-discharge nozzle to retain the fuel-discharge nozzle in a fixed position within the hollow shell.

115. The burner assembly of claim 114, wherein the tip of the hollow shell includes a threaded rim and the removable collar threadedly engages the threaded rim.

116. The burner assembly of claim 111, wherein the fuel-discharge nozzle includes a mounting fixture that selectively engages the collar and the fuel-discharge nozzle is removable from the oxygen-supply housing when the removable collar is disengaged from the mounting fixture.

117. The burner assembly of claim 116, wherein the fuel-discharge nozzle includes an inlet body portion, a central body portion, and a burner tip portion positioned to lie within the inlet opening of the burner block when the removable collar engages the mounting fixture and the oxygen-supply housing is in an installed position.

118. The burner assembly of claim 117, wherein the mounting fixture includes an outer end formed for engagement with the collar, an inner end facing the burner block, and a lip positioned to lie between the outer and inner ends and formed for engagement with the oxygen-supply housing when the collar is in the installed position.

119. The burner assembly of claim 116, wherein the mounting fixture includes an outer end formed for engagement with the collar, an inner end facing the burner block, and a lip positioned to lie between the outer and inner ends and formed for engagement with the oxygen-supply housing when the collar is in the installed position.

120. The burner assembly of claim 116, wherein the inlet opening of the burner block is defined by a wall and the burner tip portion is positioned to lie spaced-apart from the wall of the burner block when the collar is in the installed position.

REMARKS

Introduction

In accordance with 37 CFR 1.121 (b)(2)(ii), claims 1-110 and added claims 111-120 are pending in the application.

New sheets of Drawings under 37 C.F.R. §1.121(3)(i) are submitted herewith requesting amendments to Figs. 1, 3A, and 7. No new matter is believed to be added by the proposed amendments to the drawings.

The specification has been amended accordingly replacing paragraphs beginning at Col. 4 line 64, Col. 6, line 19 and at Col. 10 line 16 to reflect these amendments to the claims. Support for the amendments to the specification may be found throughout the specification and claims and in Figs. 1, 3A, and 7. No new matter is believed to be added by virtue of the amendments to the specification.

New Claims

Claims 111-120 have been added to point out more specifically the subject matter that applicant regards as his invention. The additional claims find full support through the specification and drawings. Specifically, support for the additional claims may be found at

Column 5 lines 1-9; patent claims 12, 13, 28, 50, 51, and 64, and Figs. 1, 3A, 4, and 7. No new matter is added by virtue of the new claims. Claims 111-120 are believed to be in condition for allowance.

There is no description or suggestion in the cited art of the combination including a burner block, an oxygen-supply housing, a fuel-discharge nozzle, and a removable collar engaging the oxygen-supply housing and the fuel-discharge nozzle, the collar being formed to support the fuel-discharge nozzle within the inlet opening of the burner block as recited in new claim 111. Claims 112-120 depend from claim 111.

The claims are believed to be allowable over the art references of record. Accordingly, entry of this Amendment and examination of the application leading to allowance of the claims and passage of the application to issuance is respectfully requested.

Respectfully submitted,

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INDS02 JLW 185642

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

RE: United States Patent No.: 5,458,483
Issued: October 17, 1995
Inventor: Taylor
Title: Oxygen-Fuel Burner with Integral Staged Oxygen Supply
Assignee: Maxon Corporation

OXYGEN-FUEL BURNER WITH INTEGRAL STAGED OXYGEN SUPPLY

BACKGROUND AND SUMMARY OF THE INVENTION

This application is a continuation-in-part of application Ser. No. 08/092,008, filed Jul. 15, 1993, now U.S. Pat. No. 5,431,559, issued on Jul. 11, 1995.

The present invention relates to burner assemblies, and particularly to oxygen-fuel burner assemblies. More particularly, the present invention relates to a burner having a fuel-delivery system and a staged oxygen-supply system.

One challenge facing the burner industry is to design an improved burner that produces lower nitrogen oxide emissions during operation than conventional burners. Typically, an industrial burner discharges a mixture of fuel and either air or oxygen. A proper ratio of fuel and air is established to produce a combustible fuel and air mixture. Once ignited, this combustible mixture burns to produce a flame that can be used to heat various products in a wide variety of industrial applications. Combustion of fuels such as natural gas, oil, liquid propane gas, low BTU gases, and pulverized coals often produce several unwanted pollutant emissions such as nitrogen oxides (NO_x), carbon monoxide (CO), and unburned hydrocarbons (UHC).

Burners that combine oxygen with an atomized fuel and oxygen mixture to produce a combustible mixture are known. See, for example, U.S. Pat. No. 5,092,760 to Brown and Coppin. Burners having oxygen-enrichment systems are also known as disclosed in the *IHEA Combustion Technology Manual*, Fourth Edition (1988), pp. 320–21, published by The Industrial Heating Equipment Association of Arlington, Va.

Burners were developed to burn a mixture of fuel and pure oxygen in an attempt to lower the amount of NO_x produced during combustion. Atmospheric combustion air contains approximately 79% nitrogen (N_2) and pure oxygen contains no nitrogen. It has been observed that the higher flame temperatures brought on by burning a mixture of fuel and pure oxygen has caused the conversion of fuel-bound N_2 into NO_x to increase. Additionally, new technology that allows on-site generation of combustion oxygen has been developed by oxygen suppliers. This on-site generated oxygen is not pure and can contain as much as 10% nitrogen by volume. This additional nitrogen, in contact with the high-temperature oxy-fuel flame, represents an additional source of NO_x emissions.

A burner assembly designed to burn fuel more completely using a lower flame temperature would lead to lower nitrogen oxide emissions. What is needed is a burner assembly that is able to burn a fuel and oxygen mixture without generating a lot of unwanted nitrogen oxide emissions. A staged oxygen burner designed to direct oxygen to various regions of a flame produced by the burner using modular components and easily manufactured precision oxygen-flow metering apparatus would lead to lower nitrogen oxide emissions and thus be a welcomed improvement over conventional burner assemblies. Ideally, an improved staged oxygen burner would be configured to accept various fuel nozzles to permit a user to burn either fuel gas or fuel oil at the option of the user.

According to the present invention, a burner assembly is provided for combining oxygen and fuel to produce a flame. The burner assembly includes a burner block formed to

include a flame chamber having inlet and outlet openings, bypass means for conducting oxygen outside of the flame chamber to the outlet opening of the flame chamber, and means for discharging fuel into the flame chamber formed in the burner block.

The burner assembly also includes an oxygen-supply housing including chamber means for receiving a supply of oxygen and a base wall adjacent to the burner block. The base wall is formed to include first aperture means for discharging oxygen from the chamber means into the flame chamber and second aperture means for discharging oxygen from the chamber means into the bypass means.

In preferred embodiments, pure oxygen under pressure is admitted into the chamber means. Some of this pressurized oxygen is discharged into the inlet opening of the flame chamber through the first aperture means formed in the base wall. The rest of this pressurized oxygen is discharged from the chamber means through the second aperture means formed in the base wall to bypass the flame chamber and follow predetermined paths to the outlet opening of the flame chamber.

Illustratively, a flow-metering device is provided to control flow of oxygen discharged through the first aperture means into the inlet opening of the flame chamber. The flow-metering device is formed to include a first-stage oxygen port controlling flow of oxygen into the inlet opening of the flame chamber. The second aperture means defines a second-stage oxygen port controlling flow of oxygen to the outlet opening of the flame chamber.

By establishing a fixed ratio between the effective cross-sectional area of the first-stage oxygen port and the effective cross-sectional area of the second-stage oxygen port, it is possible to proportion and control the relative flow of oxygen to each of the inlet and outlet openings of the flame chamber. Illustratively, a first set of holes is formed in the flow-metering device to define the first-stage oxygen port and a second set of holes is formed in the base wall to define the second-stage oxygen port. Advantageously, it is possible to change the fixed ratio described above simply by varying the diameter of the holes formed in the base wall at the time that those holes are created (e.g., drilled or milled).

Some of the pressurized oxygen discharged from the oxygen-supply housing chamber means (i.e., "first-stage oxygen") passes through the first aperture means and the first-stage oxygen port formed in the flow-metering device and then mixes with fuel provided by the discharging means in a first-stage region inside the flame chamber. This combustible fuel and oxygen mixture can be ignited to define a flame having a root portion in the flame chamber and a tip portion outside the flame chamber.

The burner block is also formed to include oxygen-discharge ports around the outlet opening of the flame chamber and oxygen-conducting means for conducting oxygen along one or more paths through the burner block and outside of the flame chamber to the oxygen-discharge ports. The rest of the pressurized oxygen discharged from the oxygen-supply housing chamber means passes through the second aperture means formed in the base wall into the oxygen-conducting means formed in the burner block. This "second-stage" oxygen passes through the oxygen-discharge ports and is ejected from the burner block into a downstream second-stage region containing a portion of the flame and lying outside the flame chamber.

In preferred embodiments, the burner block is made of a refractory material and includes an outside wall formed to include the flame chamber inlet opening and a plurality of

oxygen-admission ports around the inlet opening. The burner block also includes a furnace wall configured to lie in a furnace and formed to include the flame chamber outlet opening and the plurality of oxygen-discharge ports around the outlet opening.

Illustratively, the burner block is also formed to include a plurality of oxygen-conducting passageways. These passageways are formed during casting of the burner block. Each passageway extends through the burner body to connect one of the oxygen-admission ports to one of the oxygen-discharge ports. Essentially, these passageways are arranged to bypass the flame chamber and deliver second-stage oxygen to the second-stage region downstream of the flame chamber. Illustratively, the second-stage region lies in a furnace adjacent to the burner block and the flame produced by the burner assembly heats products in the furnace.

The oxygen-supply housing is provided to hold temporarily a supply of pressurized combustion oxygen for use in the burner assembly. In use, a continuous stream of pressurized oxygen is admitted into the oxygen-supply housing using any suitable means. Some of that pressurized oxygen is distributed to the first-stage region through the first aperture means and the rest of that pressurized oxygen is distributed by the bypass means to the second-stage region using the oxygen-conducting passageways formed in the burner block.

The burner assembly in accordance with the present invention introduces combustion oxygen into two regions or combustion zones. The first-stage combustion zone is near the root of the flame inside the flame chamber and the second-stage combustion zone is in the furnace itself in a location downstream from the flame chamber and nearer to the tip of the flame. Advantageously, by withholding a portion of the combustion oxygen from the root of the flame, the fuel partially burns and the fuel-bound nitrogen is converted into reducing agents. These nitrogenous compounds are subsequently oxidized to elemental nitrogen, thereby minimizing the generation of fuel nitrogen oxides. Also, the peak flame temperature is lowered in the fuel-rich first-stage combustion zone since the generated heat dissipates rapidly. This reduction in flame temperature reduces the formation of nitrogen oxides which are temperature-dependent. In the second-stage combustion zone, additional oxygen is injected through the burner block oxygen-discharge ports to complete combustion and optimize flame shape and length.

Illustratively, the burner assembly includes several modular components that can be assembled and changed easily. An oxygen-supply housing can be connected to or disconnected from a burner block using a frame and removable fasteners. A fuel nozzle module is mounted in the oxygen-supply housing so that it can be removed easily. By replacing a gas-fuel nozzle module with an oil-fuel nozzle module, it is possible to convert the burner assembly from a gas-burning unit to an oil-burning unit.

Additional features and advantages of the invention will become apparent to those skilled in the art upon consideration of the following detailed description of preferred embodiments exemplifying the best mode of carrying out the invention as presently perceived.

BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description particularly refers to the accompanying figures in which:

FIG. 1 is a perspective view of a burner assembly in accordance with the invention showing an oxygen-supply

housing coupled to a burner block, an oxygen-supply source coupled to the oxygen-supply housing, and a fuel supply source coupled to a gas-fuel nozzle module mounted in the oxygen-supply housing;

FIG. **2** is a front elevation view taken along line **2**—**2** of FIG. **1** showing four oxygen-discharge ports formed in the furnace wall of a burner block and arranged to lie around the outlet opening of a flame chamber formed in the burner block and showing three kidney-shaped oxygen-flow apertures formed in an oxygen flow-metering device and arranged to surround a fuel-discharge head of the gas-fuel nozzle module;

FIG. **3A** is a side elevation view taken along line **3A**—**3A** of FIG. **2** showing the burner block, the oxygen-supply housing containing a gas-fuel nozzle module, the fuel-discharge head of the gas-fuel nozzle module at the inlet end of a flame chamber in the burner block, first-stage means for supplying oxygen from the oxygen-supply housing through the oxygen flow-metering device appended to the fuel-discharge head into a first-stage combustion zone in the flame chamber, and second-stage means for conducting oxygen from the oxygen-supply housing to a second-stage combustion zone downstream of the flame chamber using bypass passages formed in the burner block and the frame joining the oxygen-supply housing to the burner block;

FIG. **3B** is a perspective view of the fuel-discharge head of the gas-fuel nozzle module illustrated in FIGS. **1** and **2** showing three kidney-shaped oxygen-flow apertures formed in a ring-shaped oxygen flow-metering device appended to the fuel-discharge head;

FIG. **3C** is an enlarged sectional view of a portion of the burner assembly taken along line **3C**—**3C** of FIG. **2** showing a base wall of the oxygen-supply housing, a wall aperture formed in the base wall, a larger diameter oxygen-conducting channel formed in the frame joining the oxygen-supply housing to the burner block, and an oxygen-conducting passageway formed in the burner block;

FIG. **4** is an alternative embodiment of the burner assembly of FIG. **3A** showing an annular oxygen-distributing manifold provided between the frame and the burner block;

FIG. **5** is a front elevation view taken along line **5**—**5** of FIG. **4** showing four arcuate oxygen-discharge ports formed in the furnace wall of the burner block and arranged to lie around the outlet opening of the flame chamber formed in the burner block;

FIG. **6** is an enlarged sectional view of a portion of the burner assembly taken along line **6**—**6** of FIG. **4** showing a base wall of the oxygen-supply housing, a wall aperture formed in the base wall, a larger diameter oxygen-conducting channel formed in the frame joining the oxygen-supply housing to the burner block, a circular oxygen-distributing manifold provided between the frame and the burner block, and an oxygen-conducting passageway formed in the burner block;

FIG. **7** is another alternative embodiment of the burner assembly of FIG. **3A** showing an oil-oxygen atomizing fuel nozzle module mounted in the oxygen-supply housing; and

FIG. **8** is a front elevation view taken along line **8**—**8** of FIG. **7**.

DETAILED DESCRIPTION OF THE DRAWINGS

As shown in FIG. **1**, a staged oxygen burner assembly **10** includes a burner block **12**, a frame **14** mounted on an inlet end of the burner block **12**, and a hollow oxygen-supply housing **16** mounted on the frame **14** by means of removable

fasteners 18. A fuel nozzle 20 is positioned to lie inside the hollow oxygen-supply housing 16 and is retained in place by means of a removable collar 22. It is easy to replace the fuel nozzle 20 because of the modular nature of the staged oxygen burner assembly 10. For example, to convert the staged oxygen burner assembly 10 from a gas-fired unit to an oil-fired unit, it is necessary only to replace the gas-fuel nozzle module shown in FIG. 3A with the oil-fuel nozzle module shown in FIG. 7.

Pressurized oxygen is delivered to hollow oxygen-supply housing 16 from oxygen supply 24 through conduit 26 using any suitable means. Pressurized fuel is delivered to fuel nozzle 20 from fuel supply 28 through conduit 30 using any suitable means. The oxygen-supply housing 16 cooperates with frame 14 and burner block 12 to deliver some of the combustion oxygen in oxygen-supply housing 16 to a first-stage region near the root of a flame inside the burner block 12 and the rest of the combustion oxygen to a second-stage region at a point closer to the tip of the flame outside the burner block 12. This staged oxygen burner assembly 10 meters the combustion oxygen to each stage so as to minimize unwanted nitrogen oxide emissions. The apparatus used to accomplish this oxygen-metering function is precise and easy to manufacture and use and will be described in more detail below.

The burner block 12 is formed to include a flame chamber 32 as shown in FIGS. 2 and 3A. The flame chamber 32 has an inlet opening 34 at one end and an outlet opening 36 at its opposite end. Illustratively, as shown in FIG. 2, the first-stage oxygen 37 is discharged into the inlet opening 34 of the flame chamber 32 through three kidney-shaped oxygen-flow apertures 38 and the second-stage oxygen 39 is discharged at points adjacent to the outlet opening 36 of the flame chamber 32 through four oxygen-discharge ports 40, 41, 42, 43.

As shown in FIG. 3A, burner assembly 10 is used in industrial processes to produce a flame 44 that extends into a furnace 46. Various products 48 can be conveyed through the furnace 46 to be treated or processed using heat generated by flame 44. Burner assembly 10 is configured to heat products 48 conveyed through the furnace 46 and to minimize the amount of nitrogen oxide produced during combustion. In particular, burner assembly 10 includes a staged oxygen supply system that operates to deliver some of the combustion oxygen to a first-stage region near the root of flame 44 and the rest of the combustion oxygen to a second-stage region at a point closer to the tip of flame 44. By diverting some of the combustion oxygen toward the tip of flame 44, it is possible to reduce nitrogen oxide emissions. Burner assembly 10 can be used in a wide variety of applications due to its enhanced emissions performance.

As shown in FIG. 3A, burner assembly 10 is configured to include a natural gas burner 69 of the type disclosed in U.S. Pat. No [4,690.635] 4,690,635. Illustratively, the burner 69 is mounted in the oxygen-supply housing 16 in the manner shown in FIG. 3A.

Oxygen-supply housing 16 includes a base wall 52 coupled to frame 14 by the removable fasteners 18 and a hollow shell 54 appended to the base wall 52 to define a chamber 56 for receiving a supply of pressurized oxygen 57 from the oxygen supply 24. The hollow shell 54 illustratively has a pyramidal shape and four triangular side walls 58. One of these triangular side walls 58 is formed to include an oxygen-admission port 60 coupled to the conduit 26 carrying pressurized oxygen from oxygen supply 24. Although shell 54 could have a round, square, rectangular,

or other shape, a pyramidal shape is presently preferred to conserve space in a furnace application.

As shown in FIGS. 1 and 2, the hollow shell **54** includes a tip **62** at one end and the four triangular side walls **58** extend in diverging relation from the tip **62** to the base wall **52**. Illustratively, the tip **62** is somewhat cylindrical in shape and is formed to include a central aperture **64**. A portion of the base wall **52** under the hollow shell **54** is formed to include a first aperture **66** and four second apertures **68** around the first aperture **66**. The pressurized first-stage oxygen **37** is discharged from the oxygen-supply housing chamber **56** through the first aperture **66** formed in the base wall **52**. At the same time, the pressurized second-stage oxygen **39** is discharged from the oxygen-supply housing chamber **56** through the second apertures **68** formed in the base wall **52**. Illustratively, these second apertures **68** lie in radially spaced-apart relation to the first aperture **66** and in circumferentially spaced-apart relation to one another.

A gas conduit **70** is disposed within housing **12** and has means thereon for directing a gaseous fuel therethrough to be expelled from gas conduit **70** and to mix with the oxygen for burning in a sustainable flame. Gas conduit **70** may preferably have one or more O-ring seals **72** disposed at a mounting fixture **71** formed near the outer end of the gas conduit for effectuating a seal with a rear lip portion **75** of the tip **62** of hollow shell **54**.

The natural gas burner **69** further includes a gas conduit tip or fuel-discharge head **73** connected to gas conduit **20** by gas conduit channel **76** and includes a substantially flat exterior tip face surface **78** as shown best in FIG. 3B. Exterior tip face **78** has a substantially frustoconical-shaped prominence **80** disposed thereon and protruding from tip face **78**. The flow-metering device **74** is a ring-shaped flange that is formed to include the three kidney-shaped oxygen-flow apertures **38** and appended to gas conduit tip **73** as shown in FIGS. 3A and 3B. Once the natural gas burner **69** is installed in the oxygen-supply housing **16** as shown in FIG. 3A, the frustoconical-shaped prominence **80** is positioned to extend into the inlet opening **34** of flame chamber **32** and the flow-metering device **74** is positioned to lie between the first aperture **66** in base wall **52** and the inlet opening **34**.

Gas conduit tip **73** also includes a central gas channel **82** centrally disposed therethrough and terminating at the proximal end of frustoconical-shaped prominence **80** to form substantially a knife edge-shaped rim **84** thereon. Such knife edge-shaped rim **84** structure functions to delay combustion for a few microseconds and to provide no substantial available surface for the accumulation of carbon thereon. The opening of central gas channel **82** is preferably disposed in a plane spaced at a selected distance away from the plane of tip face **78**.

The oxygen-flow apertures **38** formed in flow-metering device **74** cooperate to define a first-stage oxygen port having a first effective cross-sectional area that is equivalent to the sum of the cross-sectional areas of the three kidney-shaped oxygen-flow apertures **38**. In a presently preferred embodiment, oxygen flow apertures **38** are disposed in a circular array, which array is substantially concentric with central gas channel **82**. These oxygen-flow apertures **38** function to pass pressurized oxygen that is discharged from the oxygen-supply housing chamber **56** through the first aperture **66** into the burner block flame chamber **32** through its inlet opening **34**. In operation, pressurized oxygen from oxygen-supply housing **16** passes through oxygen-flow apertures **38** into the flame chamber **32** to mix with natural

gas or other gaseous fuel supplied through central gas channel **82** of gas conduit tip **73**. This combustible mixture is ignited in flame chamber **32** to produce flame **44** using any suitable means.

The oxygen-supply housing **16**, as shown in FIGS. **1** and 3A, is connected to a metal support block holder or frame **14** having a refractory burner block **12** retained in position with a suitable high temperature cement (not shown). The burner block **12** is made of, for example, zirconia or ZEDMUL **20C**, and is formed to include a longitudinally extending and diverging flame chamber **32**. The frame **14** has a flange portion **86** for attachment to the wall **88** of furnace **46**. As shown in FIG. 3A, the burner assembly **10** includes a nose portion **90** provided with a central discharge orifice or annular opening **92**. The nose portion **90** has a mounting flange **94** adjacent its inlet end which is suitably secured to the base wall **52** using mounting pins as shown in FIG. 3A. A gasket **96** is provided between mounting flange **94** and base wall **52** and the gasket **96** is formed to include a large opening at first aperture **66**.

As shown in FIG. 3A, the burner assembly **10** is configured to provide a first-stage combustion zone **110** in a region inside flame chamber **32** near the root **112** of flame **44** and a second-stage combustion zone **114** in a region inside furnace **46** and outside of the flame chamber **32** toward the tip **116** of flame **44**. A continuous stream of combustion oxygen **57** is supplied to oxygen-supply housing **16** through supply pipe **26** to ensure that housing **16** always contains pressurized oxygen. A first stream **37** of combustion oxygen is discharged from housing **16** into the first-stage combustion zone **110** through central discharge orifice **92** in nose portion **90** as described above. A second stream **39** of combustion oxygen is discharged from housing **16** into the second-stage combustion zone **114** through several passageways bypassing the flame chamber **32** as shown in FIG. 3A.

As shown in FIGS. **2**, 3A, and 3C, burner block **12** is formed to include four longitudinally extending bypass passageways **40**, **41**, **42**, and **43** for conducting the second stream **39** of combustion oxygen to the second-stage combustion zone **114** without passing through the flame chamber **32** formed in the burner block **12**. Burner block **12** includes an outside wall **118** that is formed to include an inlet opening **120** into each of the oxygen-conducting passageways **40**, **41**, **42**, and **43** and a furnace wall **122** that is formed to include an outlet opening for each of the oxygen-conducting passageways **40**, **41**, **42**, and **43**. The flame chamber **32** has an inlet opening **34** formed in an inner portion of burner block **12** and an outlet opening **36** formed in furnace wall **122** of burner block **12**. As shown in FIG. **2**, the four outlet openings are arranged in uniformly circumferential spaced-apart relation around the nozzle **20** and the inlet opening **34** of the flame chamber **32**. The four outlet openings are also arranged to lie in radially equidistant relation from the burner tip opening **82** as shown best in FIG. **2**.

Four oxygen-conducting channels are formed in frame **14** to conduct the second stream **39** of combustion oxygen from outlets **68** formed in the oxygen-supply housing **16** to the oxygen-conducting passageways **40**, **41**, **42**, and **43** formed in the burner block **12**. Two of these oxygen-conducting channels **124**, **126** are shown in FIG. 3A and one oxygen-conducting channel **128** is shown in greater detail in FIG. 3C. Each oxygen-delivery channel illustratively includes an inlet end **130**, an outlet end **132**, and a straight portion **134** between the inlet and outlet ends **130** and **132** as shown in FIG. 3C. It will be understood that the number and shape of the oxygen-conducting channels can vary depending upon the application and also upon the location of the housing **16**

and the inlet openings **120** into the oxygen-conducting passageways formed in the burner block **12**.

The second apertures **68** formed in the base wall **52** are sized to regulate the flow of the second stream **39** of pressurized oxygen through the oxygen-conducting channels formed in frame **14** and the oxygen-conducting passageways **40, 41, 42,** and **43** formed in the burner block **12** to the second-stage combustion zone **114**.

~~The oxygen-conducting channels formed in frame 14 and the oxygen-conducting passageways 40, 41, 42 and 43 formed in the burner block 12 cooperate to define an oxygen conductor conduit configured to conduct oxygen from the second apertures 68 formed in the base wall 52 to the second-stage combustion zone 114.~~

The internal diameter of each second aperture **68** is less than the internal diameter of the corresponding oxygen-conducting channel **128** formed in the frame **14** and the internal diameter of the corresponding oxygen-conducting passageway **41** formed in the burner block **12** as shown, for example, in FIG. 3C. Conveniently, the size of each second aperture is selected to produce the lowest nitrogen oxide emission for the desired flame shape and luminosity for the particular burner application.

The effective cross-sectional open area of the second apertures **68** is set when those apertures **68** are drilled in the base wall **52**. By reducing the internal diameter of one or more of the second apertures **68** as compared to the relatively larger internal diameters of the corresponding downstream channels and passageways formed, respectively, in the frame **14** and burner block **12**, it is possible to limit or otherwise regulate and control the flow of pressurized oxygen **39** that passes to the second-stage combustion zone **114**. It will be understood that the flow of the second stream of oxygen **39** is limited by the size of the second apertures **68** since the cross-sectional area of each aperture is preferably less than the cross-sectional area of its corresponding downstream frame channel and burner block passageway. Although it is within the scope of the present invention to make the open area of one or more second apertures **68** greater than the open area of the corresponding downstream channels and passageways, such a design would make it more difficult to change the flow of second-stage oxygen since it would now be necessary to vary the cross-sectional areas of one or more of the frame channels or burner block passageways.

It is within the scope of the present invention to proportion the flow of pressurized oxygen discharged from the oxygen-supply housing **16** into the first-stage combustion zone **110** and the second-stage combustion zone **114** by forming the oxygen-flow apertures **38** in the flow-metering device to have an effective cross-sectional area that is fixed in relation to the effective cross-sectional area of the second apertures **68** formed in base wall **52**. Essentially, these two effective cross-sectional areas are proportioned or ratioed to create a staged oxygen burner assembly having low nitrogen oxide emissions. In a presently preferred embodiment, the effective cross-sectional area of the kidney-shaped oxygen-flow apertures **38** (i.e., the first-stage oxygen port) is set during the manufacture of the flow-metering device **74** appended to the natural gas burner **69**. The ratio of oxygen flow between the first-stage combustion zone **110** and the second-stage combustion zone **114** can then be varied to suit any particular application by drilling or otherwise forming the second apertures **68** in the base wall **52** of the oxygen-supply housing **16**. It will be understood that stock housings

16 with undrilled base walls 52 can be adapted easily to change the oxygen flow ratio between the first- and second-stage combustion zones 110, 114 simply by selecting an internal diameter for each of the second apertures 68 that is calculated to achieve the desired result. Because of the modular nature of burner assembly 10, it is possible to change such staged oxygen flow ratio simply by removing the old oxygen-supply housing 16 having one set of second

apertures **68** formed in the base wall **52** and replacing it with a new oxygen-supply housing having a different set of second apertures **68**.

By shutting off or varying the flow of combustion oxygen **39** through one or more of oxygen-conducting channels formed in frame **14** and oxygen-conducting passageways **40**, **41**, **42**, and **43** formed in burner block **12**, it is possible to control the luminosity and shape of flame **44**. It has been observed that flame **44** tends to bend slightly toward an oxygen source and that a non-geometrically perfect flame may exhibit less nitrogen oxide (perhaps as a result of some imbalance in mixing fuel and oxygen).

Flame **44** can include a yellow luminous portion and a "cooler" blue non-luminous portion. In the glass industry, it is often preferred to produce a flame having a luminous portion adjacent to glass **48** heated in furnace **46**. Glass furnace operators typically prefer to position the "cooler" non-luminous portion of the flame **44** facing toward the roof **136** of the furnace **46**. This allows the furnace crown or roof **136** to run cooler, lose less heat, and extend its useful life. It has been observed that supplying oxygen to a flame causes the oxygen-rich portion of the flame to become more non-luminous.

It will be understood that is possible to vary the internal diameter of one or more second apertures **68** relative to the other second apertures **68** to control the luminosity and shape of flame **44**. It is also within the scope of the present invention to eliminate (e.g., never drill) one or more second apertures **68** in base wall **52** to block flow of pressurized oxygen into and through one or more frame channels and burner block passageways to reach the second-stage combustion zone **114**. Reference is hereby made to parent application No. 08/092,008, filed Jul. 15, 1993, which is incorporated by reference herein, for a more detailed discussion of means for regulating oxygen flow to vary flame luminosity and shape.

The burner assembly **138** shown in FIGS. **4–6** is similar to the burner assembly **10** shown in FIG. **3A**. In the embodiment of FIGS. **4–6**, the burner block **12'** is formed to include an annular channel **140** surrounding the nose portion **90** and interconnecting each of oxygen-conducting passageways **40'**, **41'**, **42'**, and **43'** in fluid communication

The frame **14'** includes means for covering the annular channel **140** to define a circular oxygen-conducting passageway **142** therebetween. This circular passageway **142** receives pressurized oxygen **39** from oxygen-conducting channels formed in the frame **14'** and connected to the second apertures **68** formed in the base wall **52** and transfers that pressurized oxygen **39** into the oxygen-conducting passageways **40'**, **41'**, **42'**, and **43'** formed in the burner block **12'**. Two outlet apertures **144**, **146** from two of the oxygen-conducting channels **148**, **150** formed in frame **14** are shown in FIG. **4**.

[AS] As shown in FIG. **5**, the oxygen-conducting passageways **40'**, **41'**, **42'**, and **43'** formed in burner block **12'** have an arcuate shape and terminate in annular openings extending around the outlet opening **36** of the flame chamber **32**. As shown in FIGS. **5** and **6**, pressurized oxygen passes in sequence from chamber **56** in oxygen-supply housing **16** through second apertures **68**, frame channels **149**, and outlet apertures **144**, **145**, **146**, and **147**, circular passageway **142**, and annular oxygen-conducting passageways **40'**, **41'**, **42'**, and **43'** to the second-stage combustion zone **114**.

The only difference between the embodiment of FIG. **7** and the embodiment of FIG. **3A** is the type of fuel nozzle module mounted in the oxygen-supply housing **16**. A natural gas nozzle **69** is used in the embodiment of FIG. **3A** and an

oil nozzle **152** is used in the embodiment of FIG. **7**. Reference is hereby made to parent application No. 08/092,008, filed Jul. 15, 1993, which, as noted above, is incorporated by reference herein, for a complete description of oil nozzle **152**.

As shown in FIG. **7**, the burner assembly **210** includes a nose portion or nose piece **90** provided with a central discharge orifice or annular opening **92**. An oil-delivery assembly **152** is shown centrally mounted within the oxygen-supply housing **16** by means of a spider or centering ring **154**. The fuel-delivery assembly **152** is shown to include an inlet body portion **155**, a central body portion **156**, and a burner tip portion **158**. A central fuel-oil passageway **160**, formed in a channel member **162**, is provided with an inlet connector for receiving a suitable supply of fuel such as oil.

The burner tip portion **158** forms a chamber **164** between a forward channel portion of the channel member **162** and the inner circumferential wall portion of the burner tip portion **158**. An atomizing member **166** is secured to an outlet end of the forward channel portion and projects within the central fuel-oil passageway **160**. The forward end of the burner tip portion **158** terminates at its outer end in a burner tip opening.

An atomizing fluid passage **168** extends through the inlet body portion **155** and central body portion **156** of the fuel assembly **152** exteriorly of channel member **162**, and communicates at its outlet end with the chamber **164** formed between the burner tip portion **158** and the channel member **162**. The atomizing fluid passage **168** is provided at its inlet end with a connector for receiving a suitable supply of atomizing fluid such as oxygen from atomizing fluid supply **169** coupled to atomizing fluid passage **168** by conduit **171**. The centering ring or spider **154** is provided with a plurality of openings or ports for the flow of oxygen outwardly along the outer surface of burner tip portion **158**.

An oxygen inlet **60** communicates with the oxygen-supply housing **16** which surrounds the central body portion **156** and the burner tip portion **158** of the fuel-delivery assembly **152**. A first portion **37** of the oxygen supplied to the housing **16** exits first aperture **66** formed in base wall **52** through the plurality of oxygen ports or openings formed in the spider or centering ring **154**, so as to provide an oxygen envelope about the atomized oil discharged from the outlet end of the fuel assembly **152**. A remaining portion **39** of the oxygen supplied to the housing **16** is diverted to flow through second apertures **68** formed in base wall **52** along a different path to reach flame **44** in the manner described above. Such diversion of combustion oxygen flow is an important feature of the staged oxygen-fuel burner assembly and contributes to the lowered nitrogen oxide emissions achieved by the burner assembly **210**.

Although the invention has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of the invention as described and defined in the following claims.

I claim:

1. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

bypass means for conducting oxygen outside of the flame chamber to the outlet opening of the flame chamber,

an oxygen-supply housing including chamber means for receiving a supply of oxygen and a base wall adjacent to the burner block, the base wall being formed to

include first aperture means for discharging oxygen from the chamber means into the flame chamber and second aperture means for discharging oxygen from the chamber means into the bypass means, and

means for discharging fuel into the flame chamber formed in the burner block, the discharging means including a nozzle extending through the chamber means and the first aperture means formed in the base wall to discharge fuel into the flame chamber.

2. The burner assembly of claim **1**, wherein the oxygen-supply housing includes a hollow shell appended to the base wall to define the chamber means therebetween.

3. The burner assembly of claim **1**, wherein the burner block is formed to include at least one oxygen-admission port lying adjacent to the base wall and communicating with the second aperture means and the bypass means is coupled to the oxygen-admission port and arranged to pass through the burner block to conduct oxygen from the chamber means through the burner block to the outlet opening of the flame chamber.

4. The burner assembly of claim **3**, wherein the oxygen-supply housing further includes a frame located between the base wall and the burner block and coupled to the burner block and fastening means for connecting the base wall to the frame and the frame is formed to include at least one oxygen-conducting channel interconnecting the second aperture means and the bypass means in fluid communication.

5. The burner assembly of claim **4**, wherein the second aperture means includes a plurality of wall apertures formed in the base wall and the burner block is formed to include an oxygen-admission port communicating with each wall aperture through one of the oxygen-conducting channels.

6. The burner assembly of claim **3**, wherein the second aperture means includes a plurality of wall apertures formed in the base wall and the burner block is formed to include an oxygen-admission port communicating with each wall aperture.

7. The burner assembly of claim **6**, further comprising frame means for supporting the burner block, the base wall being mounted on the frame means, and the frame means being formed to include oxygen-conducting channels interconnecting the wall apertures formed in the base wall and the oxygen-admission ports formed in the burner block.

8. The burner assembly of claim **1**, wherein the nozzle is one of a gas-fuel nozzle and an oil-fuel nozzle.

9. The burner assembly of claim **1**, wherein the chamber means formed in the oxygen-supply housing contains only the nozzle.

10. The burner assembly of claim **1**, wherein only the nozzle passes through the first aperture means formed in the base wall.

11. The burner assembly of claim **1**, wherein the base wall is rectangular, the first aperture means includes a first-stage aperture formed in a center portion of the rectangular base wall, and the second aperture means includes a second-stage aperture formed in each of four corner portions of the base wall and coupled to the bypass means.

12. The burner assembly of claim **1**, wherein the discharging means further includes a removable collar engaging the nozzle and threadedly engaging the oxygen-supply housing.

13. The burner assembly of claim **12**, wherein the oxygen-supply housing includes an annular lip defining a cylindrical nozzle aperture receiving the nozzle and the removable collar includes an annular side wall surrounding and engaging the annular lip.

14. The burner assembly of claim **1**, wherein the first

aperture means includes a first-stage aperture formed in the base wall, the second aperture means includes at least one second-stage aperture formed in the base wall and arranged to lie in spaced-apart relation to the first-stage aperture, the bypass means includes at least one oxygen-conducting passageway formed in the burner block and arranged to receive oxygen conducted through a corresponding second-stage aperture, and the internal diameter of each second-stage aperture formed in the base wall is less than the internal diameter of a corresponding oxygen-conducting passageway formed in the burner block to regulate flow of oxygen through the oxygen-conducting passageways formed in the burner block.

15. The burner assembly of claim **14**, where the base wall is rectangular, the first-stage aperture is formed in a center portion of the rectangular base wall, and a second-stage aperture is formed in each of four corner portions of the rectangular base wall.

16. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

bypass means for conducting oxygen outside of the flame chamber to the outlet opening of the flame chamber,

means for discharging fuel into the flame chamber formed in the burner block, and

an oxygen-supply housing including chamber means for receiving a supply of oxygen and a base wall adjacent to the burner block, the base wall being formed to include first aperture means for discharging oxygen from the chamber means into the flame chamber and second aperture means for discharging oxygen from the chamber means into the bypass means, the oxygen-supply housing including a hollow shell appended to the base wall to define the chamber means therebetween, wherein the hollow shell has a pyramidal shape and includes at least one triangular side wall appended to the base wall and formed to include an oxygen-admission port.

17. The burner assembly of claim **16**, wherein the chamber means formed in the oxygen-supply housing contains only the nozzle.

18. The burner assembly of claim **16**, wherein only the nozzle passes through the first aperture means formed in the base wall.

19. The burner assembly of claim **16**, wherein the hollow shell includes a tip and four triangular side walls diverging from the tip toward the base wall.

20. The burner assembly of claim **16**, wherein the base wall is rectangular, the first aperture means includes a first-stage aperture formed in a center portion of the rectangular base wall, and the second aperture means includes a second-stage aperture formed in each of four corner portions of the base wall and coupled to the bypass means.

21. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

bypass means for conducting oxygen outside of the flame chamber to the outlet opening of the flame chamber,

means for discharging fuel into the flame chamber formed in the burner block, and

an oxygen-supply housing including chamber means for receiving a supply of oxygen and a base wall adjacent to the burner block, the base wall being formed to include first aperture means for discharging oxygen

from the chamber means into the flame chamber and second aperture means for discharging oxygen from the chamber means into the bypass means, the oxygen-supply housing including a hollow shell appended to the base wall to define the chamber means therebetween, wherein the hollow shell includes a tip and a side wall extending between the tip and the base wall, the tip is formed to include an aperture, and the discharging means includes a nozzle extending through the aperture formed in the tip and the first aperture means formed in the base wall and terminating in the inlet opening of the flame chamber.

22. The burner of claim 21, wherein the nozzle includes a fuel-discharge head, a mounting fixture, and means for metering oxygen flow, and the tip of the hollow shell is formed to include means for supporting the mounting fixture to position the fuel-discharge head in the inlet opening and the metering means at an interface between the first aperture means and the inlet opening to regulate oxygen flowing into the inlet opening and mixing with fuel discharged by the fuel-discharge head.

23. The burner assembly of claim 21, wherein the second aperture means includes a plurality of apertures formed in the base wall and each aperture is arranged to lie in radially spaced-apart relation to a portion of the nozzle extending through the first aperture means.

24. The burner assembly of claim 21, wherein the oxygen-supply housing further includes modular fastening means for selectively connecting the base wall to the burner block so that the oxygen-supply housing and the nozzle are joined together to form a modular unit containing the first and second aperture means that is removable from the burner block at the option of a user.

25. The burner assembly of claim 21, wherein the chamber means formed in the oxygen-supply housing contains only the nozzle.

26. The burner assembly of claim 25, wherein the frame is formed to include one oxygen-conducting channel for each of the apertures formed in the base wall and included in the second aperture means.

27. The burner assembly of claim 21, wherein the base wall is rectangular, the first aperture means includes a first-stage aperture formed in a center portion of the rectangular base wall, and the second aperture means includes a second-stage aperture formed in each of four corner portions of the base wall and coupled to the bypass means.

28. The burner assembly of claim 21, wherein discharging means further includes a removable collar engaging the tip of the hollow shell and the nozzle to retain the nozzle in a fixed position in the chamber means.

29. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

bypass means for conducting oxygen outside of the flame chamber to the outlet opening of the flame chamber,

means for discharging fuel into the flame chamber formed in the burner block, and

an oxygen-supply housing including chamber means for receiving a supply of oxygen and a base wall adjacent to the burner block, the base wall being formed to include first aperture means for discharging oxygen from the chamber means into the flame chamber and second aperture means for discharging oxygen from the chamber means into the bypass means, the oxygen-supply housing further including a hollow shell appended to the base wall to define the chamber means

therebetween and modular fastening means for selectively connecting the base wall to the burner block to position the first aperture means in confronting relation to the inlet opening of the flame chamber so that the oxygen-supply housing can be disconnected from the burner block during rehabilitation of the burner assembly, the modular fastening means including a frame positioned to lie between the base wall and the burner block, means for coupling the frame to the burner block, and fasteners interconnecting the base wall and the frame.

30. The burner assembly of claim **29**, wherein the frame is formed to include at least one oxygen-conducting channel interconnecting the second aperture means formed in the base wall and the bypass means.

31. The burner assembly of claim **29**, wherein the base wall is rectangular, the first aperture means includes a first-stage aperture formed in a center portion of the rectangular base wall, the second aperture means includes a second-stage aperture formed in each of four corner portions of the base wall and coupled to the bypass means, and the frame is formed to include one oxygen-conducting channel for each of the first-stage and second-stage apertures.

32. The burner assembly of claim **29**, wherein the second aperture means includes a plurality of apertures formed in the base wall, the bypass means includes a plurality of passageways formed in the burner block, and the frame is formed to include at least one oxygen-conducting channel interconnecting one of the plurality of apertures and the plurality of passageways in fluid communication.

33. The burner assembly of claim **29**, wherein the second aperture means includes at least one second-stage aperture formed in the base wall, at least one oxygen-conducting channel formed in the frame and arranged to receive oxygen conducted through a corresponding second-stage aperture, the bypass means includes at least one oxygen-conducting passageway formed in the burner block and arranged to receive oxygen conducted through a corresponding second-stage aperture and oxygen-conducting channel, and the internal diameter of each second-stage aperture formed in the base wall is less than the internal diameter of both of a corresponding oxygen-conducting channel formed in the frame and a corresponding oxygen-conducting passageway formed in the burner block to regulate flow of oxygen through the oxygen-conducting passageways formed in the burner block.

34. The burner assembly of claim **29**, wherein the burner block is formed to include a plurality of oxygen-conducting passageways defining the bypass means and an annular channel surrounding the inlet opening of the flame chamber and interconnecting each of the oxygen-conducting passageways, the frame includes means for covering the annular channel to define a circular oxygen-conducting passageway between the frame and the burner block and at least one oxygen-conducting channel interconnecting the second aperture means formed in the base wall and the circular oxygen-conducting passageway.

35. The burner assembly of claim **34**, wherein the oxygen-conducting passageways formed in the burner block have an arcuate shape and terminate in annular openings formed in the burner block and arranged to lie around the outlet opening of the flame chamber formed in the burner block.

36. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

bypass means for conducting oxygen outside of the flame

chamber to the outlet opening of the flame chamber,

means for discharging fuel into the flame chamber formed in the burner block,

an oxygen-supply housing including chamber means for receiving a supply of oxygen and a base wall adjacent to the burner block, the base wall being formed to include first aperture means for discharging oxygen from the chamber means into the flame chamber and second aperture means for discharging oxygen from the chamber means into the bypass means, the burner block being formed to include at least one oxygen-admission port lying adjacent to the base wall and communicating with the second aperture means and the bypass means being coupled to the oxygen-admission port and arranged to pass through the burner block to conduct oxygen from the chamber means through the burner block to the outlet opening of the flame chamber, the second aperture means including a plurality of wall apertures formed in the base wall, the burner block being formed to include an oxygen-admission port communicating with each wall aperture, and frame means for supporting the burner block, the base wall being mounted on the frame means, the burner block being formed to include an annular channel around the inlet opening of the flame chamber, the frame means including means for covering the annular channel to define an annular oxygen-conducting passageway therein and means for communicating oxygen discharged from the chamber means through the wall apertures to the annular oxygen-conducting passageway for delivery to the outlet opening of the flame chamber through the bypass means.

37. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

bypass means for conducting oxygen outside of the flame chamber to the outlet opening of the flame chamber,

means for discharging fuel into the flame chamber formed in the burner block, and

an oxygen-supply housing including chamber means for receiving a supply of oxygen and a base wall adjacent to the burner block, the base wall being formed to include first aperture means for discharging oxygen from the chamber means into the flame chamber and second aperture means for discharging oxygen from the chamber means into the bypass means, the discharging means including a fuel discharge nozzle and means for fixing the fuel discharge nozzle in the inlet opening, the fixing means being positioned to lie between the base wall and the burner block, the fixing means being formed to include third aperture means for conducting oxygen discharged through the first aperture means into the flame chamber, the third aperture means defining a first-stage oxygen port having a first effective cross-sectional area and communicating oxygen from the chamber means into the flame chamber, the second aperture means defining a second-stage oxygen port having a second effective cross-sectional area less than the first effective cross-sectional area and communicating oxygen from the chamber means to the outlet opening of the flame chamber through the bypass means.

38. The burner assembly of claim 37, wherein the third aperture means includes a flange appended to the fuel discharge nozzle and formed to include the first-stage oxy-

gen port and the second aperture means includes a plurality of apertures formed in the base wall collectively to define the second-stage oxygen port.

39. The burner assembly of claim 38, wherein the flange is ring-shaped and is formed to include a plurality of apertures lying around the fuel-discharge nozzle and defining the first-stage oxygen port and each of the apertures formed in the base wall lies in radially spaced-apart relation to the fuel-discharge nozzle.

40. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

a nozzle including means for discharging fuel into the flame chamber formed in the burner block,

means for fixing the nozzle adjacent to the burner block to position the discharging means at the inlet opening of the flame chamber so that a primary combustion zone is established in the flame chamber between the inlet and outlet openings,

means for supplying oxygen to the flame chamber through the inlet opening so that the oxygen supplied by the supplying means mixes with the fuel discharged by the nozzle in a first-stage region inside the flame chamber to produce a combustible mixture that can be ignited in the primary combustion zone to define a flame having a root portion in the flame chamber and a tip portion outside the flame chamber,

first-stage metering means for metering the flow rate of oxygen from the supplying means into the flame chamber through the inlet opening, the first-stage metering means being appended to the nozzle,

bypass means for delivering oxygen from the supplying means into a downstream second-stage region containing a portion of the flame and lying outside the flame chamber to supplement oxygen supplied to the first-stage region inside the flame chamber by the supplying means, and

second-stage metering means for metering the flow rate of oxygen from the supplying means into the bypass means so that the downstream second-stage region outside the flame chamber through the bypass means is fixed in proportion to the flow rate of oxygen passing through the first-stage metering means.

41. The burner assembly of claim 40, wherein fixing means includes a ring-shaped flange positioned to lie around the nozzle and formed to include at least one oxygen-flow aperture defining the first-stage metering means.

42. The burner assembly of claim 41, wherein the supplying means includes an oxygen-supply housing including chamber means for receiving a supply of oxygen and a base wall adjacent to the burner block and the fixing means further includes a support fixture coupled to the base wall and the ring-shaped flange.

43. The burner assembly of claim 42 wherein the support fixture includes a mounting flange fixed between the base wall and the burner block and a nose portion formed to include a central aperture and the ring-shaped flange is positioned to lie in the central aperture and is coupled to the nose portion to support the nozzle in the inlet opening of the flame chamber.

44. The burner assembly of claim 40, wherein the supplying means includes an oxygen-supply housing including chamber means for receiving a supply of oxygen and a base wall adjacent to the burner block, the fixing means includes a support fixture having a mounting flange fixed between the

base wall and the burner block and a nose portion, the nose portion being formed to include a central opening receiving the nozzle, and the first-stage metering means includes a partition positioned to lie between the nozzle and the nose portion and formed to include the at least one oxygen-flow aperture.

45. The burner assembly of claim **44**, wherein the partition is a ring-shaped flange surrounding the nozzle.

46. The burner assembly of claim **44**, wherein the partition is positioned to lie in the central aperture of the nose portion.

47. The burner assembly of claim **40**, wherein the supplying means includes an oxygen-supply housing including chamber means for receiving a supply of oxygen and a base wall adjacent to the burner block and the second-stage metering means includes at least one aperture formed in the base wall and arranged to interconnect to chamber means and the bypass means in fluid communication.

48. The burner assembly of claim **47**, wherein the oxygen-supply housing includes a hollow shell appended to the base wall to define the chamber means therebetween.

49. The burner assembly of claim **48**, wherein the base wall is formed to include first aperture means for discharging oxygen from the chamber means to the first-stage metering means, the hollow shell includes a tip and a side wall extending between the tip and the base wall, the tip is formed to include an aperture, the nozzle is mounted to extend through the aperture formed in the tip and the first aperture means formed in the base wall and to terminate in the outlet opening of the flame chamber, and the first-stage metering means includes a flow-metering ring appended to the nozzle and formed to include at least one oxygen-flow aperture.

50. The burner assembly of claim **40**, wherein the nozzle includes a fuel-discharge head and a mounting fixture, the first-stage metering means is appended to the fuel-discharge head, the supplying means includes an oxygen-supply housing and the fixing means includes first support means for supporting the mounting fixture to position the fuel-discharge head in the inlet opening and second support means for supporting the first-stage metering means in a location between the oxygen-supply housing and the inlet opening.

51. The burner assembly of claim **50**, wherein the supplying means includes an oxygen-supply housing including a hollow shell formed to include an aperture receiving the mounting fixture of the nozzle and the first support means includes a collar engaging the hollow shell to retain the mounting fixture in the aperture.

52. The burner assembly of claim **50**, wherein the second support means includes a mounting flange fixed between the base wall and the burner block and a nose portion formed to include a central aperture receiving the fuel-discharge head.

53. The burner assembly of claim **50**, wherein the first-stage metering means includes a ring positioned to lie around the fuel-discharge head and formed to include at least one oxygen-flow aperture.

54. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

bypass means for conducting oxygen outside of the flame chamber to the outlet opening of the flame chamber,

an oxygen-supply housing including chamber means for receiving a supply of oxygen,

frame means for coupling the oxygen-supply housing to the burner block,

a fuel nozzle module having a nozzle body and a dis-

charge tip, and

means for supporting the nozzle body of the fuel nozzle module in the chamber means to aim the discharge tip of the fuel nozzle module into the inlet opening of the flame chamber.

55. The burner assembly of claim **54**, wherein the oxygen-supply housing includes a hollow shell forming a boundary of the chamber means and the supporting means includes an aperture formed in the hollow shell and configured to receive the nozzle body therein and means for retaining the nozzle body in the aperture formed in the hollow shell so that the nozzle body is mounted inside the chamber means.

56. The burner assembly of claim **55**, wherein the supporting means further includes means for holding the discharge tip in a fixed position in the inlet opening of the flame chamber.

57. The burner assembly of claim **51**, wherein the oxygen-supply housing includes a base wall coupled to the hollow shell to define the chamber means therebetween and the holding means is coupled to the base wall.

58. The burner assembly of claim **54**, wherein the fuel nozzle module includes means for conducting fuel through the nozzle body and discharging fuel at the discharge tip.

59. The burner assembly of claim **54**, wherein the fuel nozzle module includes means for conducting separate streams of fuel and oxygen through the nozzle body and discharging an oxygen and fuel mixture using fuel and oxygen from the separate streams at the discharge tip.

60. A burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening, and

an oxygen-supply housing including a base wall and a hollow shell appended to the base wall to define an oxygen-supply chamber for receiving a supply of oxygen, the base wall being formed to include an oxygen-discharge aperture, the base wall being fixed to lie adjacent to the burner block to place the oxygen-discharge aperture in the base wall in fluid communication with the inlet opening in the burner block to allow oxygen to pass from the oxygen-supply chamber to the flame chamber through the oxygen-discharge aperture, the hollow shell having a pyramidal shape and a plurality of triangular side walls.

61. The burner assembly of claim **60**, wherein each triangular side wall has a wide base end and a narrow tip end, and the narrow tip ends of the triangular side walls cooperate to define a nozzle-receiving aperture, and further comprising a fuel-discharge nozzle mounted in the nozzle-receiving aperture and arranged to discharge fuel into the flame chamber through the inlet opening in the burner block.

62. The burner assembly of claim **61**, wherein the fuel-discharge nozzle is positioned to extend through the oxygen-discharge aperture formed in the base wall.

63. The burner assembly of claim **61**, wherein the wide base of each triangular side wall is appended to the base wall.

64. The burner assembly of claim **61**, further comprising a removable collar engaging the fuel-discharge nozzle and threadedly engaging a threaded rim appended to the narrow tip ends of the triangular side walls.

65. The burner assembly of claim **60**, further comprising a connector coupled to the oxygen-supply housing and the burner block to mount the oxygen-supply housing on the burner block.

66. The burner assembly of claim **65**, wherein the connector includes a frame positioned to lie between the base wall and the burner block and formed to include an oxygen-

conductor passageway interconnecting the oxygen-discharge aperture formed in the base wall and the inlet opening formed in the burner block.

67. The burner assembly of claim **66**, wherein the base wall is formed to include another oxygen-discharge aperture communicating with the oxygen-supply chamber, the burner block is formed to include an oxygen-conducting passageway having an outlet in the frame chamber and an inlet, and the frame is formed to include a bypass passageway inter-

connecting said another oxygen-discharge aperture formed in the base wall and said oxygen-conducting passageway formed in the burner block.

68. The burner assembly of claim **66**, wherein the connector further includes at least one fastener coupled to the base wall and frame.

* * * * *

69. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

an oxygen conductor conduit configured to conduct oxygen along a route outside of the flame chamber to the outlet opening of the flame chamber,

an oxygen-supply housing defining an oxygen chamber configured to receive a supply of oxygen and a base wall positioned to lie adjacent to the burner block, the base wall being formed to include a first-stage aperture positioned to lie in alignment with the inlet opening and to pass oxygen from the oxygen chamber into the flame chamber and a second-stage aperture arranged to lie in spaced-apart relation to the first-stage aperture to pass oxygen from the oxygen chamber into the oxygen conductor conduit, the internal diameter of the second-stage aperture being less than the internal diameter of the oxygen conductor conduit to regulate the flow of oxygen from the oxygen chamber through the oxygen conductor conduit, and

a fuel-discharge nozzle positioned to lie adjacent to the inlet opening and configured to discharge fuel into the flame chamber formed in the burner block.

70. The burner assembly of claim 69, wherein the base wall is formed to include a plurality of second-stage apertures and the burner block is formed to include at least one inlet opening lying adjacent to the base wall and communicating with each second-stage aperture.

71. The burner assembly of claim 70, wherein the oxygen conductor conduit includes a plurality

of oxygen-conducting passageways formed in the burner block and each oxygen-conducting passageway corresponds to and communicates with one of the second-stage apertures formed in the base wall.

72. The burner assembly of claim 71, further comprising a frame supporting the burner block and wherein the base wall is mounted on the frame, the oxygen conductor conduit further includes oxygen-conducting channels formed in the frame, and the oxygen-conducting channels interconnect the second-stage apertures formed in the base wall and the inlet openings formed in the burner block.

73. The burner assembly of claim 70, wherein the base wall is rectangular, the first-stage aperture is formed in a center portion of the rectangular base wall and one second-stage aperture in each of four corner portions of the base wall.

74. The burner assembly of claim 69, further comprising a frame coupled to the burner block and positioned to lie adjacent the base wall and a fastener configured to connect the base wall to the frame and wherein the oxygen conductor conduit includes an oxygen-conducting channel formed in the frame and arranged to interconnect the second-stage aperture and the oxygen-conducting passageway.

75. The burner assembly of claim 69, wherein the fuel-discharge nozzle passes through the first-stage aperture formed in the base wall.

76. The burner assembly of claim 69, wherein the oxygen-supply housing includes a hollow shell appended to the base wall to define the oxygen chamber therebetween.

77. The burner assembly of claim 76, wherein the hollow shell has a pyramidal shape and includes at least

one triangular side wall appended to the base wall and formed to include an oxygen-admission port.

78. The burner of claim 76, wherein the hollow shell includes a tip and a side wall extending between the tip and the base wall, the tip is formed to include an aperture, and the fuel-discharge nozzle extends through the aperture formed in the tip and the first-stage aperture formed in the base wall and terminates in the inlet opening of the flame chamber.

79. The burner of claim 78, wherein the fuel-discharge nozzle includes a fuel-discharge head positioned to lie in the inlet opening, a mounting fixture, and a flow-metering device positioned to lie at an interface between the first-stage aperture and the inlet opening to regulate oxygen flowing into the inlet opening and mixing with fuel discharged by the fuel-discharge head.

80. The burner assembly of claim 79, wherein the base wall is formed to include a plurality of second-stage apertures and each second-stage aperture is arranged to lie in radially spaced-apart relation to a portion of the fuel-discharge nozzle extending through the first-stage aperture.

81. The burner assembly of claim 79, wherein the oxygen-supply housing further includes a fastener configured to selectively connect the base wall to the burner block so that the oxygen-supply housing and the fuel-discharge nozzle are joined together to form a modular unit containing the first-stage aperture and the second-stage aperture that is removable from the burner block at the option of a user.

82. The burner of claim 76, further comprising a frame selectively coupled to the burner block and positioned to lie adjacent to the base

wall and a fastener configured to selectively connect the base wall to the frame to position the first-stage aperture in confronting relation to the inlet opening of the flame chamber so that the oxygen-supply housing can be disconnected from the burner block during rehabilitation of the burner assembly.

83. The burner of claim 82, wherein the burner block is formed to include an annular channel extending around the inlet opening of the flame chamber.

84. The burner of claim 83, wherein the frame covers the annular channel to define an annular oxygen-conducting passageway therein forming a portion of the oxygen conductor conduit and communicates oxygen discharged from the chamber through the second-stage apertures to the annular oxygen-conducting passageway for delivery to the outlet opening of the flame chamber through the oxygen conductor conduit.

85. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

an oxygen conductor conduit configured to conduct oxygen outside of the flame chamber to the outlet opening of the flame chamber,

an oxygen-supply housing defining an oxygen chamber configured to receive a supply of oxygen and a base wall positioned to lie adjacent to the burner block, the base wall being formed to include a first-stage aperture in alignment with the inlet opening to pass oxygen from the oxygen chamber into the flame chamber and a second-stage aperture arranged to lie in spaced-apart relation to the first-stage aperture to pass

oxygen from the oxygen chamber into the oxygen conductor conduit, and

a fuel-discharge nozzle extending through the oxygen chamber and the first-stage aperture formed in the base wall to discharge fuel into the flame chamber.

86. The burner assembly of claim 85, wherein the oxygen-supply housing includes a hollow shell appended to the base wall to define the oxygen chamber therebetween.

87. The burner assembly of claim 85, wherein the burner block is formed to include at least one oxygen inlet lying adjacent to the base wall and communicating with the second-stage aperture and the oxygen conductor conduit is coupled to the oxygen inlet and arranged to pass through the burner block to conduct oxygen from the oxygen chamber through the burner block to the outlet opening of the flame chamber.

88. The burner assembly of claim 87, wherein the oxygen-supply housing further includes a frame located between the base wall and the burner block and coupled to the burner block and a fastener connecting the base wall to the frame and the oxygen conductor conduit includes at least one oxygen-conducting channel formed in the frame and connected to the second-stage aperture.

89. The burner assembly of claim 88, wherein the base wall is formed to include a plurality of second-stage apertures and the burner block is formed to include an inlet opening communicating with each second-stage aperture through one of the oxygen-conducting channels.

90. The burner assembly of claim 87, wherein the base wall is formed to include a plurality of second-stage apertures and the burner block is formed to include an inlet opening communicating with each

second-stage aperture through one of the oxygen-conducting channels.

91. The burner assembly of claim 90, further comprising a frame supporting the burner block, the base wall being mounted on the frame, and the oxygen conductor conduit including oxygen-conducting channels formed in the frame to interconnect the second-stage apertures formed in the base wall and the oxygen inlets formed in the burner block.

92. The burner assembly of claim 85, wherein the oxygen chamber formed in the oxygen-supply housing contains only the fuel-discharge nozzle.

93. The burner assembly of claim 85, wherein only the fuel-discharge nozzle passes through the first-stage aperture formed in the base wall.

94. The burner assembly of claim 85, wherein the base wall is rectangular, the first-stage aperture is formed in a center portion of the rectangular base wall, and the second-stage aperture is formed in each of four corner portions of the base wall and coupled to the oxygen conductor conduit.

95. The burner assembly of claim 85, further comprising a removable collar engaging the fuel-discharge nozzle and threadedly engaging the oxygen-supply housing.

96. The burner assembly of claim 95, wherein the oxygen-supply housing includes an annular lip defining a cylindrical nozzle aperture receiving the fuel-discharge nozzle and the removable collar includes an annular side wall surrounding and engaging the annular lip.

97. The burner assembly of claim 85, wherein first-stage aperture is formed in the base wall, the second-stage aperture is formed in the base wall and arranged to lie in

spaced-apart relation to the first-stage aperture, the oxygen conductor conduit includes at least one oxygen-conducting passageway formed in the burner block and arranged to receive oxygen conducted through a corresponding second-stage aperture, and the internal diameter of each second-stage aperture formed in the base wall is less than the internal diameter of a corresponding oxygen-conducting passageway formed in the burner block to regulate flow of oxygen through the oxygen-conducting passageways formed in the burner block.

98. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

an oxygen conductor conduit configured to conduct oxygen outside of the flame chamber to the outlet opening of the flame chamber,

a fuel-discharge nozzle positioned to lie in the inlet opening and configured to discharge fuel into the flame chamber of the burner block,

an oxygen-supply housing defining an oxygen chamber configured to receive a supply of oxygen and a base wall positioned to lie adjacent to the burner block, the base wall being formed to include a first-stage aperture positioned to pass oxygen from the oxygen chamber into the flame chamber and a second-stage aperture positioned to pass oxygen from the oxygen chamber into the oxygen conductor conduit, the second-stage aperture defining a second-stage oxygen port having a first effective cross-sectional area and communicating oxygen from the chamber to the outlet opening of the

flame chamber through the oxygen-conducting passageway, and

a flange positioned to lie between the base wall and the burner block and to extend about the fuel-discharge nozzle to fix the fuel-discharge nozzle in the inlet opening, the flange being formed to include a third-stage aperture for conducing oxygen discharged through the first-stage aperture into the flame chamber, the third-stage aperture defining a first-stage oxygen port having a second effective cross-sectional area that is greater than the first effective cross-sectional area and communicating oxygen from the oxygen chamber into the flame chamber.

99. The burner assembly of claim 98, wherein the base wall is formed to include a plurality of second-stage apertures that collectively define the second-stage oxygen port.

100. The burner assembly of claim 99, wherein the flange is ring-shaped and is formed to include a plurality of apertures lying around the fuel-discharge nozzle and defining the first-stage oxygen port and each of the apertures formed in the base wall lies in radially spaced-apart relation to the fuel-discharge nozzle.

101. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

a fuel-discharge nozzle positioned to lie in the inlet opening and configured to discharge fuel into the flame chamber formed in the burner block,

a flange positioned to lie around the fuel-discharge nozzle to situate the fuel-discharge nozzle

adjacent to the burner block at the inlet opening of the flame chamber so that a primary combustion zone is established in the flame chamber between the inlet and outlet openings and the flange is formed to include at least one oxygen-flow aperture therethrough,

an oxygen-supply housing including an oxygen chamber configured to receive a supply of oxygen and a base wall adjacent to the burner block, the base wall being formed to include a first-stage aperture sized to supply oxygen to the flame chamber through the inlet opening so that the oxygen supplied by the first-stage aperture mixes with the fuel discharged by the fuel-discharge nozzle in a first-stage region inside the flame chamber to produce a combustible mixture that can be ignited in the primary combustion zone to define a flame having a root portion in the flame chamber and a tip portion outside the flame chamber,

a partition positioned to lie between the fuel-discharge nozzle and the flange and formed to include at least one oxygen-flow aperture therethrough, the partition being configured to meter the flow rate of oxygen from the oxygen chamber into the flame chamber through the inlet opening, the partition being appended to the fuel-discharge nozzle,

an oxygen conductor conduit configured to conduct oxygen from the oxygen chamber into a downstream second-stage region containing a portion of the flame and lying outside the flame chamber to supplement oxygen supplied to the first-stage region inside the flame chamber by the first-stage aperture, and

at least one aperture formed in the base wall and arranged to interconnect the oxygen chamber and the oxygen conductor conduit in fluid communication, the at least one

aperture being sized to meter the flow rate of oxygen from the oxygen chamber into the oxygen conductor conduit so that the flow rate of oxygen passing the downstream second-stage region outside the flame chamber through the oxygen conductor conduit is fixed in proportion to the flow rate of oxygen passing through the partition.

102. The burner assembly of claim 101, wherein the flange is ring-shaped.

103. The burner assembly of claim 102, wherein the flange includes a support fixture coupled to the base wall.

104. The burner assembly of claim 103, wherein the support fixture includes a mounting flange fixed between the base wall and the burner block and a nose portion formed to include a central aperture and the ring-shaped flange is positioned to lie in the central aperture and is coupled to the nose portion to support the fuel-discharge nozzle in the inlet opening of the flame chamber.

105. The burner assembly of claim 101, wherein the flange includes a support fixture having a mounting flange fixed between the base wall and the burner block and a nose portion, the nose portion being formed to include a central opening receiving the fuel-discharge nozzle.

106. The burner assembly of claim 96, wherein the partition is a ring-shaped flange surrounding the fuel-discharge nozzle.

107. The burner assembly of claim 105, wherein the partition is positioned to lie in the central aperture of the nose portion.

108. The burner assembly of claim 101, wherein the fuel-discharge nozzle includes a fuel-discharge head and a mounting fixture, the partition is appended to the fuel-discharge head,

and the flange supports the mounting fixture to position the fuel-discharge head in the inlet opening and supports the partition in a location between the oxygen-supply housing and the inlet opening.

109. The burner assembly of claim 108, wherein the oxygen-supply housing includes a hollow shell formed to include an aperture receiving the mounting fixture of the fuel-discharge nozzle and the flange includes a collar engaging the hollow shell to retain the mounting fixture in the aperture.

110. A burner assembly for combining oxygen and fuel to produce a flame, the burner assembly comprising

a burner block formed to include a flame chamber having an inlet opening and an outlet opening,

an oxygen conductor conduit configured to conduct oxygen outside of the flame chamber to the outlet opening of the flame chamber,

an oxygen-supply housing including a hollow shell defining an oxygen chamber configured to receive a supply of oxygen, the hollow shell being formed to include an aperture therein,

a frame configured to couple the oxygen-supply housing to the burner block,

a fuel nozzle module having a nozzle body and a discharge tip, the fuel nozzle module extending through the aperture formed in the hollow shell to aim the discharge tip of the fuel nozzle module into the inlet opening of the flame chamber.

The oxygen-conducting channels formed in frame 14 and the oxygen-conducting passageways 40, 41, 42 and 43 formed in the burner block 12 cooperate to define an oxygen conductor conduit configured to conduct oxygen from the second apertures 68 formed in the base wall 52 to the second-stage combustion zone 114.

[4,690.635] 4,690,635.

[AS] As

[57] ABSTRACT

A burner assembly is provided for combining oxygen and fuel to produce a flame. The burner assembly includes a burner block formed to include a flame chamber having inlet and outlet openings, a bypass structure for conducting oxygen outside of the flame chamber to the outlet opening of the flame chamber and structure for discharging fuel into the flame chamber formed in the burner block.

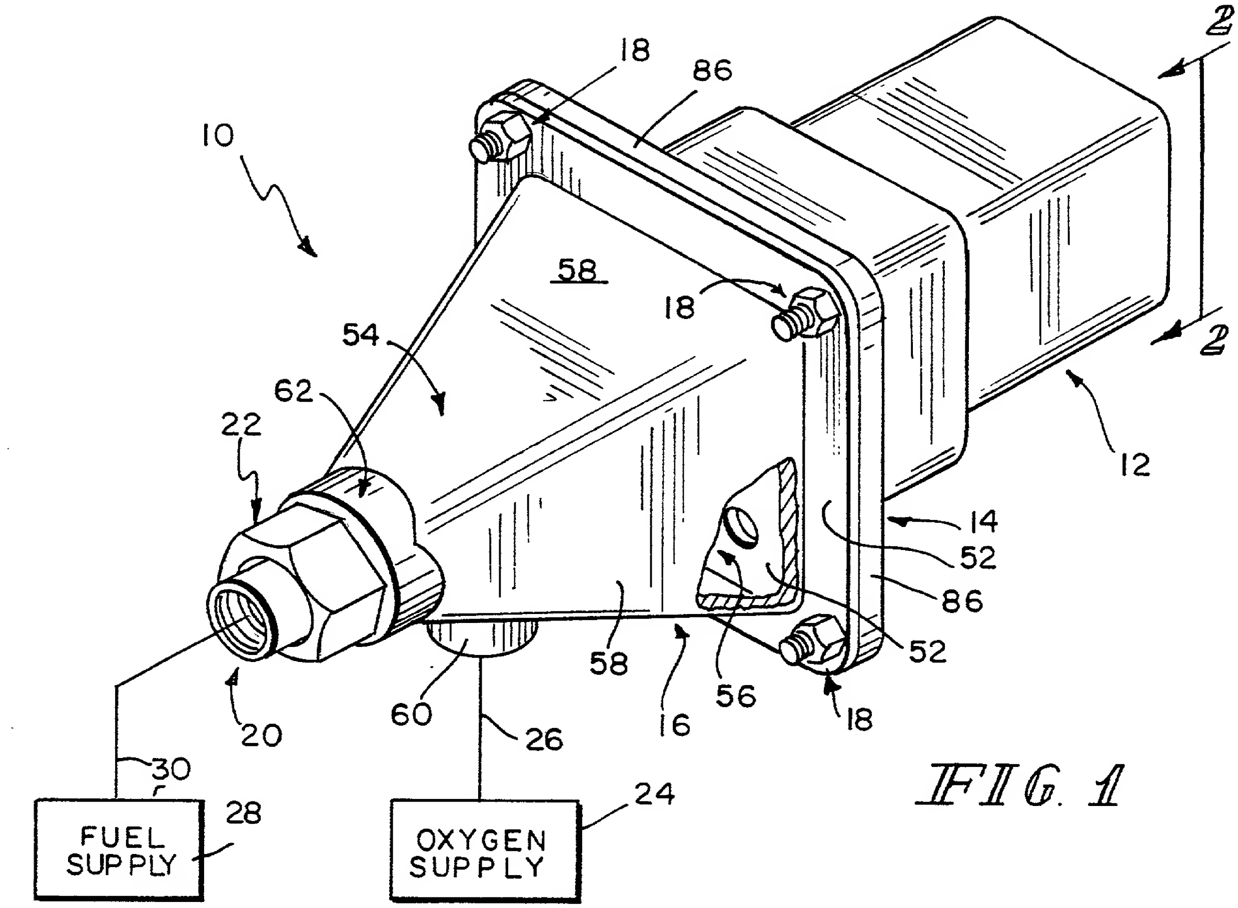

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FIG. 1

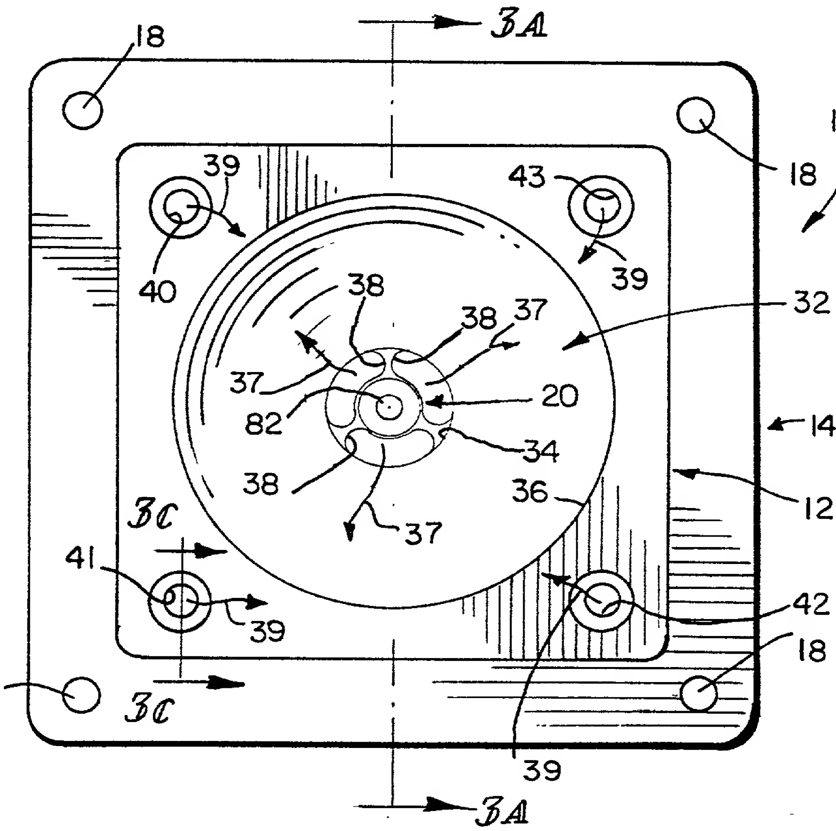

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FIG. 2

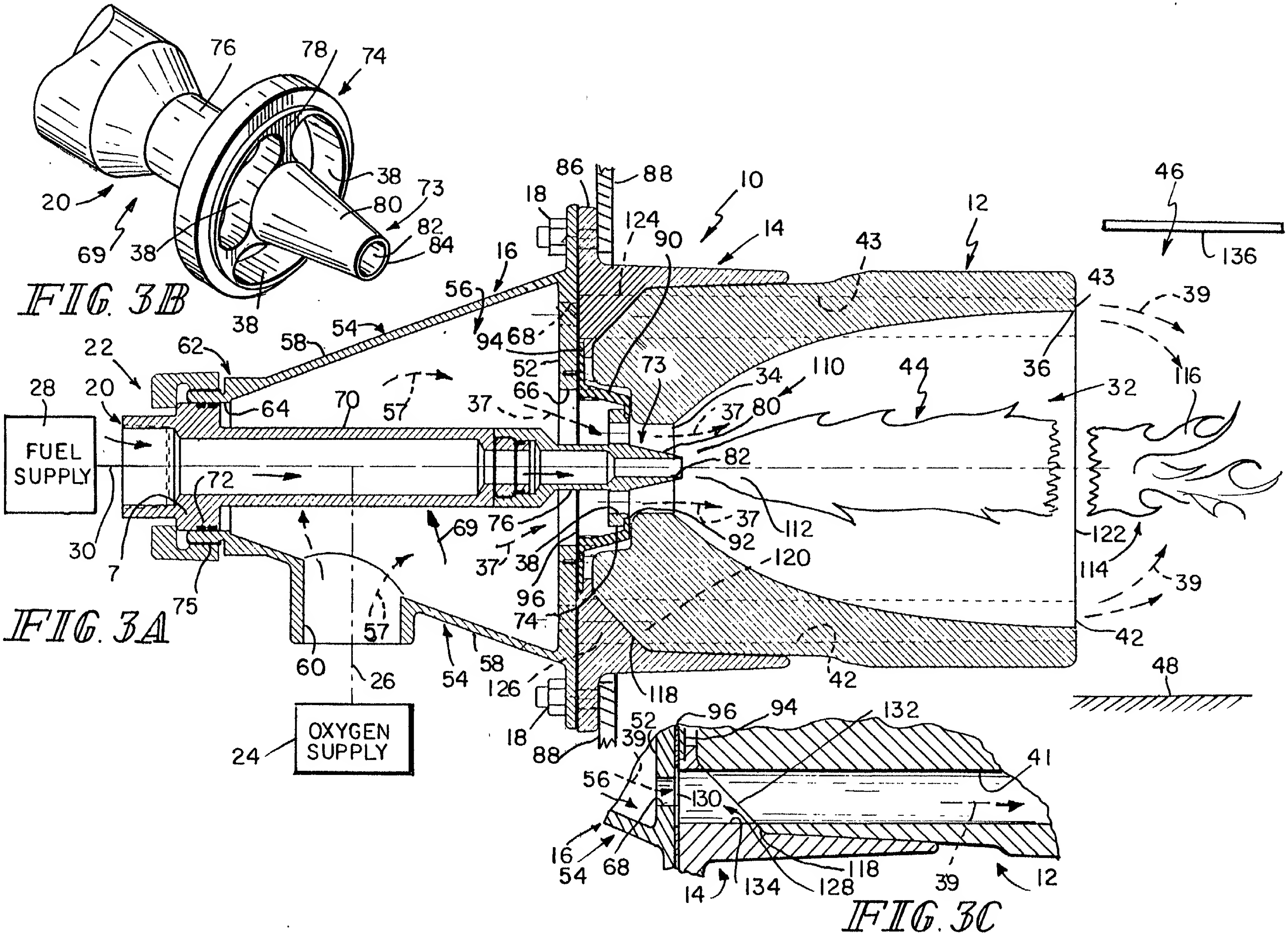

FIG. 3B

FIG. 3A

FIG. 3C

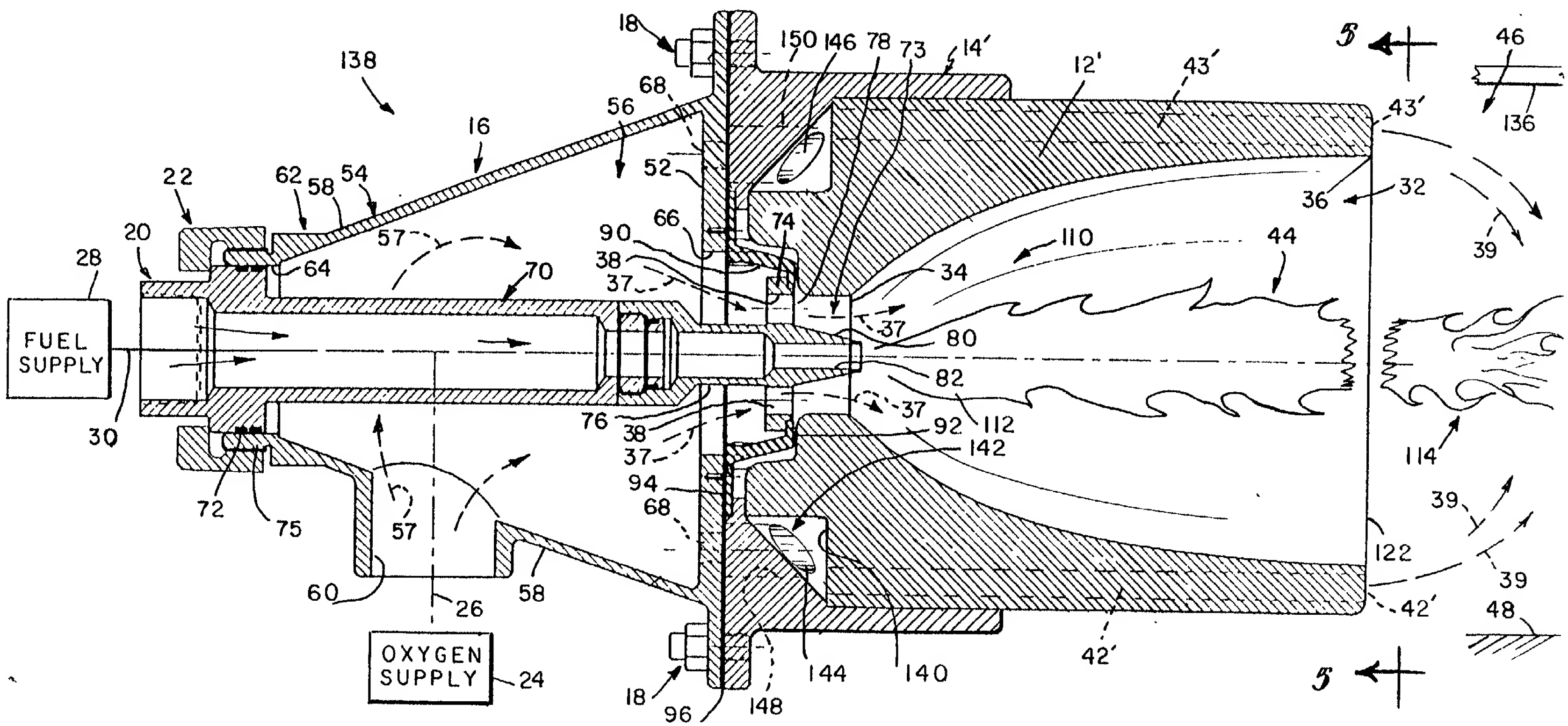

FIG. 4

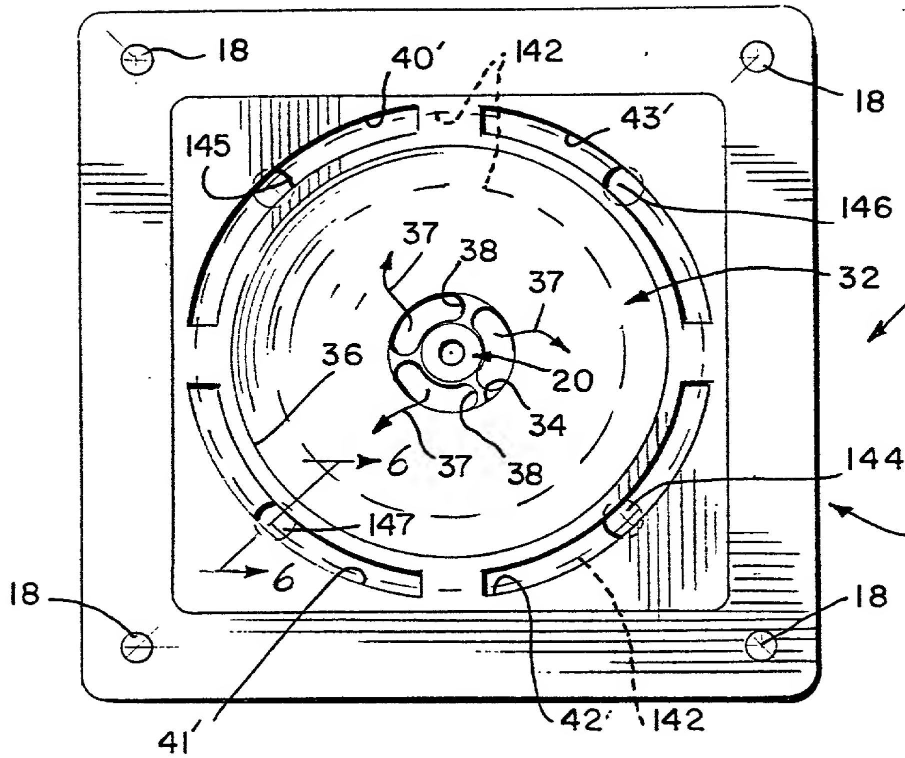
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FIG. 5

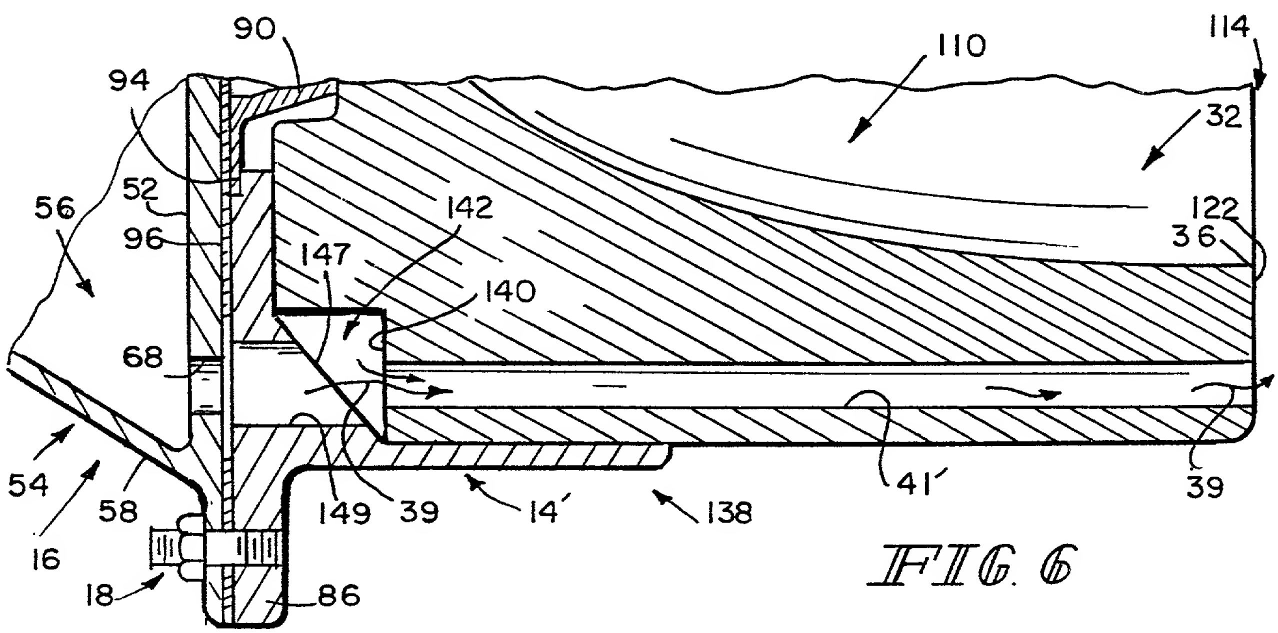
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FIG. 6

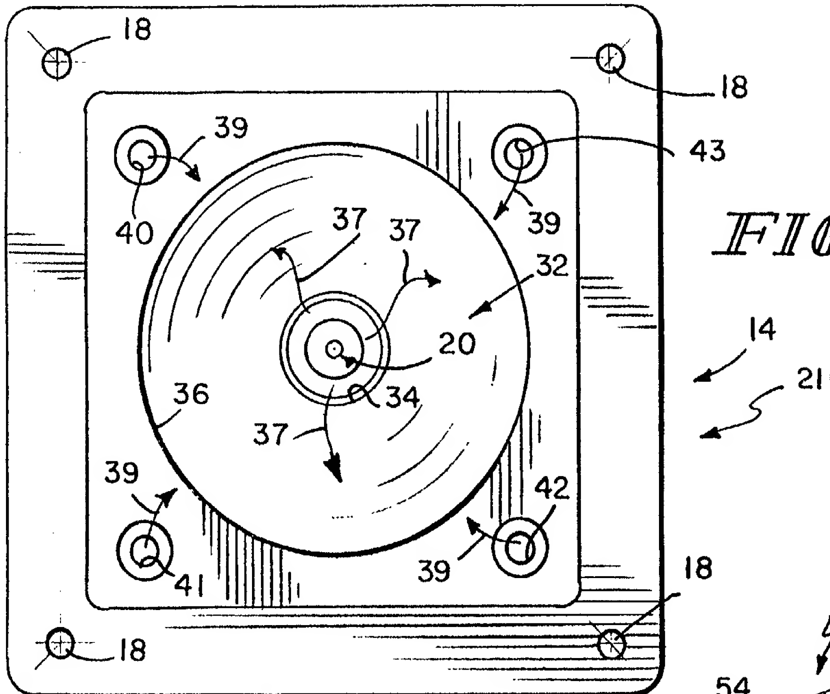
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FIG. 8

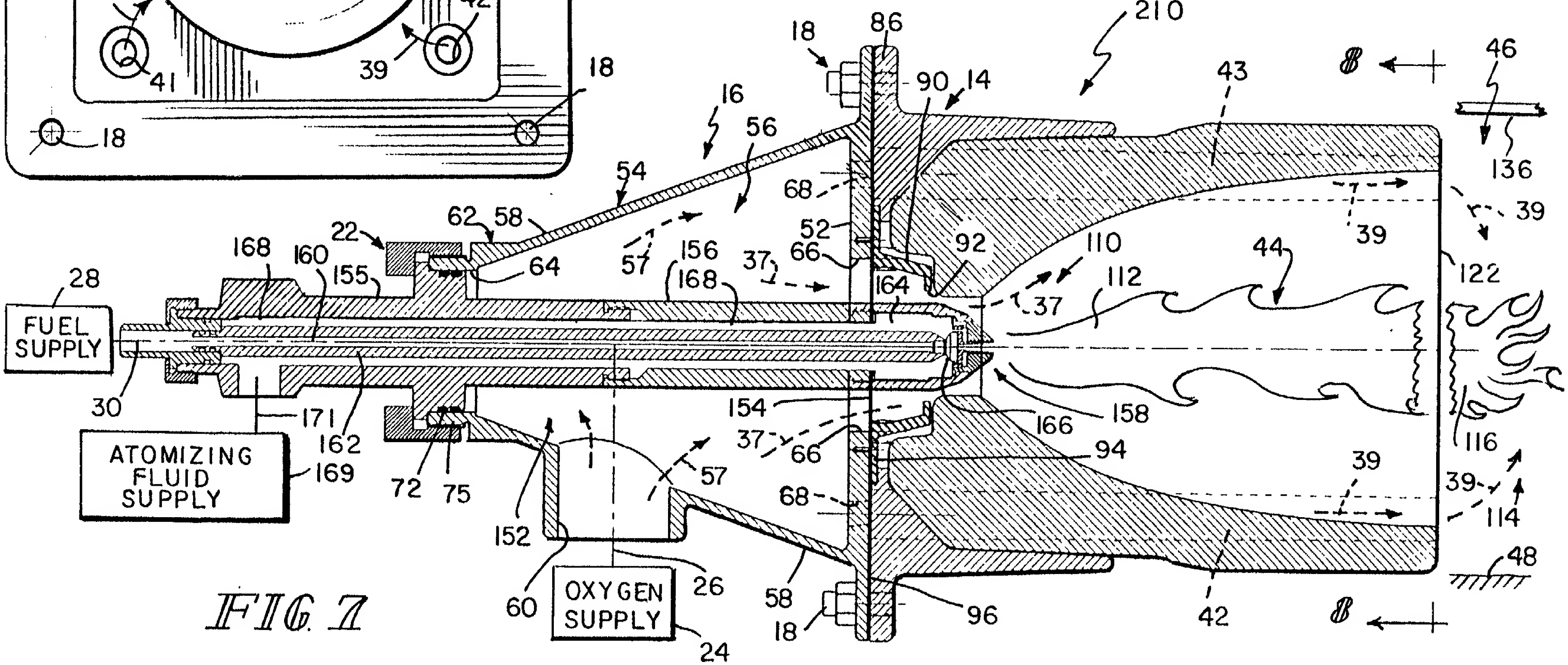
FUEL SUPPLY
ATOMIZING FLUID SUPPLY
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FIG. 7

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OIPE JC54 AUG 0 7 1998 PATENT & TRADEMARK OFFICE

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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group: Unknown

Attorney Docket: 3053-28781

Applicant: Curtis L. Taylor

Invention: OXYGEN-FUEL BURNER WITH INTEGRAL STAGED OXYGEN SUPPLY

Serial No: 08/954,291

Filed: October 17, 1997

Examiner: Unknown

Certificate Under 37 CFR 1.8(a)

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to Assistant Commissioner for Patents, Washington, D.C. 20231

on Aug 4, 1998

Jill L. Woodburn
Jill L. Woodburn (Reg. No. 39,874)

Dated: Aug. 4, 1998

Application To Reissue
U.S. Patent No. 5,458,483
Issued October 17, 1995
on U.S. Application Serial No 163,424
Filed December 8, 1993

SUPPLEMENTAL DECLARATION BY INVENTOR

Box: Missing Parts
Assistant Commissioner
for Patents
Washington, D.C. 20231

Sir.

I, Curtis L Taylor, declare that I am a citizen of the United States of America; that I verily believe myself to be the sole, original, and first inventor of the invention described and claimed in U.S. Letters Patent No 5,458,483 (hereinafter '483 PATENT) and in the foregoing specification and for which invention I solicit a reissue patent; that I do not know and do not believe that said invention was ever known or used in the United States of America before my invention thereof; that I disclosed and claimed in the '483 PATENT a burner

assembly (See, e.g., claim 1 in the '483 PATENT) comprising "a burner block . . . bypass means. . an oxygen-supply housing including chamber means for receiving a supply of oxygen and a base wall . the base wall being formed to include first aperture means . . . and second aperture means and means for discharging fuel into the flame chamber formed in the burner block, the discharging means including a nozzle extending through the chamber means and the first aperture means formed in the base wall to discharge fuel into the flame chamber"; that during the preparation and prosecution of the application that led to the '483 PATENT I believed that the claim covered structure illustrated in Figs. 2, 3A, 3B, 4, 5, 7, and 8 in the '483 PATENT, that subsequent to the issuance of the '483 PATENT I became aware of a potential infringement of the claims of the '483 PATENT; that in January 1997, in connection with reviewing that potential infringement, my attorneys reviewed the claims of the '483 PATENT, in July 1997, my attorneys carefully reviewed the specification and claims of the '483 PATENT and realized that it was not necessary to include claim limitations covering the nozzle and the "means plus function" language to define a patentable invention in claims for a burner assembly, that I have unsuccessfully sought to obtain the potentially infringing device; that I have considered the results of the evaluation of the specification and claims by my attorneys; and that accordingly, I now verily believe the '483 PATENT to be wholly or partly inoperative or invalid by reason of my claiming less that I had a right to claim in the '483 PATENT.

I request that I be permitted to amend the '483 PATENT and be granted a reissue patent, that errors rendering the '483 PATENT wholly or partly inoperative or invalid caused the claims of such patent to be of more narrow scope than necessary to distinguish over the prior art; that such errors arose because I and my patent attorneys did not appreciate the overly narrow character of the claims at the time I made the invention and prepared and

prosecuted the application that matured into the '483 PATENT; and that such errors arose through error and without any deceptive intent

Specifically, I claimed less than I had a right to claim in the '483 PATENT by claiming claims 1-39 covering burner assemblies comprising "bypass means" "chamber means", "first aperture means", "second aperture means", and "discharging means"; claims 40-53 covering burner assemblies comprising a burner block, a nozzle, "fixing means", supplying means", first-stage metering means", bypass means", and second-stage metering means"' claims 54-59 covering burner assemblies comprising a burner block, "bypass means", an oxygen-supply housing, "frame means", a fuel nozzle module, and "supporting means"; and claims 60-68 comprising a burner block and an oxygen-supply housing including a hollow shell having a pyramidal shape and a plurality of triangular side walls I seek to add new claims 69-120.

I also seek to amend Fig 1 of the drawings by adding a reference numeral 220 referring to an outer surface of removable collar 22, reference numeral 222 referring to an inner surface of removable collar 22, reference numeral 224 referring to an external side wall of removable collar 22; and reference numerals 226 referring to bounding surfaces of side wall 224. In addition, I seek to amend Fig. 3A of the drawings by changing reference numeral 7 referring to a mounting fixture of gas conduit 70 to reference numeral 71 and by adding a reference numeral 72 referring to O-ring seals; reference numeral 220 referring to an outer surface of removable collar 22; reference numeral 222 referring to an inner surface of removable collar 22; reference numeral 228 referring to an internal side wall of removable collar 22, reference numeral 230 referring to a passageway between outer and inner surfaces 220, 222; reference numeral 232 referring to a threaded portion of internal side wall 228; reference numerals 234 referring to a limit tab of internal side wall 228, reference numeral

236 referring to a recess in internal side wall 228; reference numerals 239 referring to an inner surface of rear lip portion 75; reference numerals 240 referring to an outer surface of rear lip portion 75; reference numeral 250 referring to an outer end of mounting fixture 71; and reference numerals 252 referring to an inner end of mounting fixture 71.

I also seek to amend Fig. 7 of the drawings by adding reference numeral 22 referring to the removable collar, reference numeral 34 referring to an inlet opening of flame chamber 32; reference numerals 35 referring to a wall defining inlet opening 34; reference numeral 220 referring to an outer surface of removable collar 22; reference numeral 222 referring to an inner surface of removable collar 22; reference numerals 271 referring to a mounting fixture on body portion 155 of fuel-delivery assembly 152; reference numeral 228 referring to an internal side wall of removable collar 22, reference numeral 232 referring to a threaded portion of internal side wall 228; reference numeral 234 referring to a limit tab of internal side wall 228; reference numeral 236 referring to a recess in internal side wall 228; reference numerals 239 referring to an inner surface of rear lip portion 75; reference numeral 240 referring to an outer surface of rear lip portion 75; reference numerals 350 referring to an outer end of mounting fixture 271, reference numerals 352 referring to an inner end of mounting fixture 271, and reference numeral 254 referring to a lip portion of mounting fixture 271 adjacent outer end 350.

I also seek to amend the specification at Col. 5 line 55, Col. 8 line 8; Col. 9 line 43; and Col. 9 line 54, to make changes that correspond to the language set out in the new claims and to correct typographical errors. As recited in the attached Preliminary Amendment, I also seek to replace the paragraphs beginning at Col 4 line 64, Col 6 line 19; and Col. 10 line 6 to reflect the amendments to Figs 1, 3A, and 7. No new matter is believed to be added by virtue of the amendments to the specification.

I also seek to correct the References Cited on the face of the '483 PATENT by adding in the U.S. Patent Documents --4,351,632 9/1982 Nagal-- and by adding --Foreign Patent Documents 2,048,456 12/1980 United Kingdom; 143,307 11/1980 Japan; and 340,006 4/1981 Japan--. The references were cited during prosecution of the '483 PATENT, (see the PTO-1449 in Attachment A) but were not listed on the face of the '483 PATENT.

Newly presented independent claim 69 claims structurally a burner assembly that includes a burner block formed to include a flame chamber having an inlet opening and an outlet opening, an oxygen conductor conduit configured to conduct oxygen along a route outside of the flame chamber to the outlet opening, and an oxygen-supply housing defining an oxygen chamber configured to receive a supply of oxygen and a base wall positioned to lie adjacent to the burner block. Claim 69 also requires that the base wall includes a first-stage aperture positioned to lie in alignment with the inlet opening and to pass oxygen from the oxygen chamber into the flame chamber and a second-stage aperture arranged to lie in spaced-apart relation to the first-stage aperture to pass oxygen from the oxygen chamber into the oxygen conductor conduit. In addition, claim 69 also requires that the internal diameter of the second-stage aperture is less than the internal diameter of the oxygen conductor conduit to regulate the flow of oxygen from the oxygen chamber through the oxygen conductor conduit and that a fuel-discharge nozzle is positioned to lie adjacent to the inlet opening and is configured to discharge fuel into the flame chamber formed in the burner block. Newly presented claim 69 eliminates details regarding the nozzle and "means plus function" language not needed to define patentability over the prior art. Newly presented claims 70-84 depend from claim 69 and recite in more detail features of the oxygen conductor conduit, the base wall, the oxygen-supply housing, and the fuel-discharge nozzle.

Claim 85 differs from patent claim 1 in that it eliminates "means for" language found throughout. Newly presented independent claim 85 instead recites structural details of a burner assembly that includes a burner block formed to include a flame chamber having an inlet opening and an outlet opening, an oxygen conductor conduit configured to conduct oxygen outside of the flame chamber to the outlet opening of the flame chamber, an oxygen-supply housing defining an oxygen chamber configured to receive a supply of oxygen and a base wall positioned to lie adjacent to the burner block. Claim 85 also requires that the base wall includes a first-stage aperture in alignment with the inlet opening to pass oxygen from the oxygen chamber into the flame chamber and a second-stage aperture arranged to lie in spaced-apart relation to the first-stage aperture to pass oxygen from the oxygen chamber into the oxygen conductor conduit. In addition, claim 85 requires that a fuel-discharge nozzle extends through the oxygen chamber and the first-stage aperture to discharge fuel into the flame chamber. Newly presented claims 86-97 depend from claim 85 and recite in more detail features of the oxygen-supply housing, the burner block and recite a frame and a removable collar.

Newly presented independent claim 98 differs from patent claim 29 in that it eliminates "means for" language found throughout. Newly presented independent claim 98 instead recites structural details of a burner assembly that includes a burner block with a flame chamber having an inlet opening and an outlet opening, an oxygen conductor conduit configured to conduct oxygen outside of the flame chamber to the outlet opening of the flame chamber, a fuel-discharge nozzle positioned to lie in the inlet opening and configured to discharge fuel into the flame chamber of the burner block, and an oxygen-supply housing defining an oxygen chamber configured to receive a supply of oxygen and a base wall positioned to lie adjacent to the burner block. Claim 98 also requires that the base wall

includes a first-stage aperture positioned to pass oxygen from the oxygen chamber into the flame chamber and a second-stage aperture positioned to pass oxygen from the oxygen chamber into the corresponding oxygen conductor conduit. In addition, claim 98 requires that the second-stage aperture defines a second-stage oxygen port with a first effective cross-sectional area and communicating oxygen from the oxygen chamber to the outlet opening of the flame chamber through the oxygen conductor conduit and that a flange is positioned to lie between the base wall and the burner block to extend about the fuel-discharge nozzle to fix the fuel-discharge nozzle in the inlet opening. Claim 98 further requires that the flange includes a third-stage aperture for conducing oxygen discharged through the first-stage aperture into the flame chamber and that the third-stage aperture defines a first-stage oxygen port having a first-stage oxygen port having a second effective cross-sectional area that is greater than the first effective cross-sectional area and communicates oxygen from the oxygen chamber into the flame chamber. Claims 99-100 depend from claim 98 and recite in more detail features of the base wall and the flange.

Newly presented independent claim 101 differs from patent claim 40 in that it eliminates "means for" language found throughout Newly presented independent claim 101 instead recites structural details of burner assembly comprising a burner block formed to include a flame chamber having an inlet opening and an outlet opening, a fuel-discharge nozzle positioned to lie in the inlet opening and configured to discharge fuel into the flame chamber formed in the burner block, a flange positioned to lie around the fuel-discharge nozzle to situate the fuel-discharge nozzle adjacent to the burner block at the inlet opening of the flame chamber so that a primary combustion zone is established in the flame chamber between the inlet and outlet openings and the flange is formed to include at least one oxygen-flow aperture therethrough, and an oxygen-supply housing including an oxygen chamber configured to

receive a supply of oxygen and a base wall adjacent to the burner block. Claim 101 further requires that the base wall includes a first-stage aperture sized to supply oxygen to the flame chamber through the inlet opening so that the oxygen supplied by the first-stage aperture mixes with the fuel discharged by the fuel-discharge nozzle in a first-stage region inside the flame chamber to produce a combustible mixture that can be ignited in the primary combustion zone to define a flame having a root portion in the flame chamber and a tip portion outside the flame chamber. In addition, claim 101 requires that a partition is appended to the fuel-discharge nozzle, positioned to lie between the fuel-discharge nozzle and the flange, and formed to include at least one oxygen-flow aperture therethrough and the partition is configured to meter the flow rate of oxygen from the oxygen chamber into the flame chamber through the inlet opening. Further, claim 101 requires that an oxygen conductor conduit is configured to conduct oxygen from the oxygen chamber into a downstream second-stage region containing a portion of the flame and lying outside the flame chamber to supplement oxygen supplied to the first-stage region inside the flame chamber by the first-stage aperture and at least one aperture is formed in the base wall and arranged to interconnect the oxygen chamber and the oxygen conductor conduit in fluid communication, the at least one aperture being sized to meter the flow rate of oxygen from the oxygen chamber into the oxygen conductor conduit so that the flow rate of oxygen passing to the downstream second-stage region outside the flame chamber through the oxygen conductor conduit is fixed in proportion to the flow rate of oxygen passing through the partition. Newly presented claims 102-109 depend from claim 101 and recite in more detail features of the oxygen conductor conduit and the second-stage aperture. The claims depending from claim 101 also recite a frame and features of the base wall, the fuel-discharge nozzle, and the oxygen-supply housing.

Newly presented independent claim 110 differs from patent claim 54 in that it omits the "means for" language throughout. Newly presented claim 110 specifically recites a burner assembly that includes a burner block that includes a flame chamber having an inlet opening and an outlet opening, an oxygen conductor conduit configured to conduct oxygen outside of the flame chamber to the outlet opening of the flame chamber, an oxygen-supply housing that includes a hollow shell that defines an oxygen chamber configured to receive a supply of oxygen and includes an aperture therein, a frame configured to couple the oxygen-supply housing to the burner block, and a fuel nozzle module that has a nozzle body and a discharge tip. In addition, claim 110 requires that the fuel nozzle module extends through the aperture formed in the hollow shell to aim the discharge tip of the fuel nozzle module into the inlet opening of the flame chamber.

Newly presented independent claim 111 differs from patent claim 1 in that it eliminates "means for' language found throughout and eliminates the bypass means element and the second aperture means of the oxygen supply element. Newly presented claim 111 recites structurally a burner assembly that includes a combination having a burner block, an oxygen-supply housing, a fuel-discharge nozzle, and a removable collar engaging the oxygen-supply housing and the fuel-discharge nozzle, the collar being formed to support the fuel-discharge nozzle within the inlet opening of the burner block Newly presented claims 112-120 depend from claim 111 and recite in more detail features of the removable collar and the fuel-discharge nozzle.

I have reviewed and understand the contents of the specification, including the claims, as amended by all the amendments referred to above.

I acknowledge my duty to disclose information of which I am aware which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56; and I

further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under 18 U.S.C § 1001, and that such willful false statements may jeopardize the validity of the application for reissue or any patent issuing thereon.

I hereby appoint William R. Coffey, Reg. No. 24023, Jerry E. Hyland, Reg. No. 20904; Richard D. Conard, Reg No. 27321, Steven R. Lammert, Reg. No. 27653; Richard A. Rezek, Reg. No. 30796; Timothy E. Niednagel, Reg. No. 33266; John P. Breen, Reg. No 38833, Jill L. Werling, Reg No 39874, Nancy J. Harrison, Reg. No. 27083; R. Trevor Carter, Reg. No 40549, Perry Palan, Reg. No. 26213, Mark M. Newman, Reg. No. 31472; Bobby B. Gillenwater, Reg. No. 31105; Paul B. Hunt, Reg. No. 37154; Michael S. Gzybowski, Reg. No. 32816; and Robert D. Null, Reg No. 40746, my attorneys, with full power of substitution and revocation, to prosecute this application, and to transact all business in the Patent and Trademark Office connected therewith; and I specify that communications regarding this application to reissue be directed to:

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8|4|98
Date

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ASSENT BY ASSIGNEE

The undersigned assignee of the entire interest in the above-mentioned Letters Patent hereby assents to the accompanying DECLARATION BY INVENTORS.

MAXON CORPORATION

By: William P. Coppin

Printed Name: WILLIAM P. COPPIN

Title: VP. ENGINEERING

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